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Table 11. Fillers Suitable for Silicone Polymers*

Filler	Particle size		Reinforcement produced in silicone gums	
	Mean diameter, μm	Surface area, m^2/g	Tensile strength, MPa^b	Elongation, ϵ
<i>Reinforcing</i>				
silica aerogel	0.03	110-150	4.1-6.9	200-350
fumed silica	0.015-0.02	175-200	4.1-12.4	200-600
acetylene black	0.045	78-85	4.1-6.2	200-350
<i>Semireinforcing and nonreinforcing</i>				
flux-calcined diatomaceous silica	1-5	< 5	2.7-5.5	75-200
calcined diatomaceous silica	1-5	< 5	2.7-5.5	75-200
calcined kaolin	1-5	< 5	2.7-5.5	75-200
precipitated calcium carbonate	0.03-0.05	32	2.7-4.1	100-300
ground silica	5-10		0.7-2.8	200-300
ground silica	1-10		0.7-2.8	200-300
ground silica	5		0.7-2.8	200-300
zinc oxide	0.3	3.0	1.4-3.5	100-300
iron oxide	<1		1.4-3.5	100-300
zirconium silicate			2.8-4.1	100-300
titanium dioxide	0.3		1.4-3.5	300-400

* Ref. 352.

^b To convert MPa to psi, multiply by 145.

compound. In an early method the filler is treated with chlorosilanes or other reactive silanes, and the HCl or other reaction products are removed by purging the filler mass with an inert gas (354). Cyclic siloxane oligomers are now widely used to treat filler for silicone elastomers (350).

The extremely high surface silicas used as fillers present the same storage and handling problems as the fluffy carbon blacks. Typical bulk densities for fumed silicas as collected from the fuming operation are 32-80 kg/m³. They can be increased to 160-240 kg/m³ by mechanical compaction and deaeration, but even this density requires a large storage area for a reasonable working supply. Bulk shipping techniques continue to improve. Filler is frequently transported in bags, from which it may be fed to conveyors or sent to bulk storage. Semi-fluidized pneumatic transfer to and from specially designed rail cars and storage silos is practical, but requires attention to loss at the point of discharge. Automatic equipment for weighing the proper charge of filler to batch compounding systems can be adapted to handling low density silicas. From a safety standpoint, handling any finely divided filler requires respirators or dust masks. However, the fumed oxides are in the form of spheres of amorphous silica, which, in contrast to crystalline silica dust, are considered incapable of inducing silicosis (355).

Oligomers of polydimethylsiloxane can be polymerized in the presence of fillers. Uncatalyzed base compounds for both RTV and heat-curing elastomers can be made in this way. However, optimal properties still depend on conventional compounding (356).

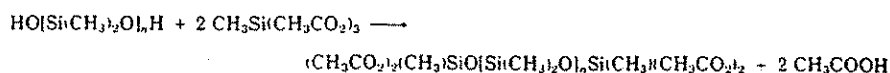
RTV Rubbers. Room temperature vulcanizing (RTV) silicone elastomers are supplied as uncured rubbers with liquid or pastelike consistencies. They are based on polymers of intermediate molecular weights and viscosities, eg,

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100–1,000,000 mm²/s at 25°C. Curing is based on chemical reactions that increase molecular weights and provide cross-linking; catalysts ensure cure control. The RTV silicone rubbers are available in two modifications. The cure reactions of one-component products are triggered by exposure to atmospheric moisture. Those of two-component products are triggered by mixing the two components, one of which consists of or contains the catalyst; the two components are supplied separately.

Fluids with silanol end groups are employed for most one-component products (340). The most widely used products are cured by reactions involving acetoxysilanes (357–360).



Cure is accelerated and controlled by catalysts, especially tin soaps (361). In the above sequence methyltriacetoxysilane functions as a vehicle for polymer chain extension and cross-linking. Analogous products based on methyltris(2-ethylhexanoyloxy)silane are also available (362). Cure proceeds by hydrolytic cleavage of the acyloxy group from silicon, followed by condensation of the silanol group formed with another acyloxy silicon, and so on. Evaporation of the acid by-product drives the reaction toward completion. The tin catalyst probably functions by forming an active complex with polymer silanol, which reacts with the cross-linking agent (363,364).

Other cure systems proceed similarly, but employ different silane curing agents. Commercial products based on methoxysilanes and catalyzed by titanium compounds (eg, chelates) sometimes have the advantage of releasing a hydrolysis product that is not acidic (365–368). Other products employ methoxy-functional cures catalyzed by tin compounds; methanol scavengers can be used to protect the polymer from tin-catalyzed alcoholysis. Alkoxysilanes are slower cross-linking agents than acetoxysilanes. Promoters are sometimes employed to get sufficiently fast cures (369–372). Acetone is the by-product from methyltris(isopropenoxysilane (373,374). Products based on amino-, amido-, and ketoxysilanes are also available (375–377).

The most common cross-linkers are trifunctional silanes. Tetrafunctional silanes provide faster cures; eg, cure times with tetraethoxysilane are shorter than with triethoxysilanes. Small multifunctional siloxane oligomer molecules can also be used, such as $[\text{R}_n\text{X}_{3-n}\text{Si}]_2\text{O}$, where $n = 0-3$, R is alkyl, and X is the reactive function (343,363). The fillers and additives used in these products must be compatible with the curing agent; that is, they must be dry.

The one-component RTV rubbers are made by mixing polymers, fillers, additives, curing agents, and catalysts. The mixture is packaged to protect it from moisture, which may trigger cure. The time required for cure depends on the curing system, temperature, humidity, and thickness of the silicone layer. Under

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typical ambient conditions the surface can be tack free in 15–30 min; a 0.3-cm thick layer cures in less than one day. As cure progresses, strength develops slowly for about three weeks (340,378,379).

The original viscosity of these RTV materials depends principally on that of the polymer components and the filler loading. Filler and original polymer properties and cross-link density affect the ultimate strength of the fully cured elastomer; most commercial products are based on polydimethylsiloxanes. Polymers with substituents other than methyl modify and improve certain properties; eg, trifluoropropyl groups improve solvent resistance. Some products are compounded with fillers and additives to be pourable, and others to be thixotropic. Silica-filled polydimethylsiloxane systems, lacking pigments and other additives, cure to form translucent rubbers. Since the specific gravity of silicas (ca 2.2) exceeds that of siloxanes (ca 1.0), the specific gravity of the RTV rubbers depends on the filler loading. Physical properties of similar cured acetox RTV formulations are shown in Table 12 (380).

Table 12. Physical Properties of RTV Rubbers^a

Specific gravity ^a	Durometer hardness.		Tensile strength,	Elongation, %
	Shore A		MPa ^c	
1.18	45		2.4	180
1.30	50		3.1	140
1.33	50		3.4	200
1.37	55		3.8	120
1.45	60		4.5	110
1.45	60		5.2	160
1.48	65		4.8	110

^a Ref. 380.^b With increasing filler loading.^c To convert MPa to psi, multiply by 145.

Formulations with different curing systems, polymer molecular weights and structures, cross-link densities, and other characteristics offer a broad spectrum of product properties. For example, one-component products are available with elongations as high as 1000%. Typical properties of representative cured RTV silicone rubbers are shown in Tables 13 and 14 (378,379,381–387).

Table 13. Cure Properties of Typical RTV Silicone Rubbers^a

Property	One component		Two components	
	General purpose	Construction sealant	Adhesive sealant	Molding compound
hardness, Shore A, durometer	30	22	50	60
tensile strength, MPa ^b	2.4	1.0	3.4	5.5
elongation, %	400	850	200	220
tear strength, J/cm ^{2c}	0.80	0.35	0.52	1.75

^a Refs. 378, 379, 381–385.^b To convert MPa to psi, multiply by 145.^c To convert J/cm² to lb/in., multiply by 57.1.

Table 14. Thermal and Electrical Properties of Cured Silicone Elastomers*

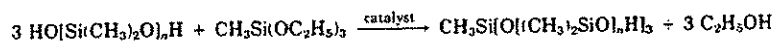
Property	Typical range
useful temperature range, °C	-60 to 250
with thermal stabilizers	-110 to 250
thermal conductivity, W/m·K	1.7-3.4
coefficient of thermal expansion, per °C	3.5×10^{-5}
dielectric strength, V/μm	20
dielectric constant at 100 Hz	3.5-4.5
dissipation factor at 100 Hz	0.01-0.02
volume resistivity, Ω·cm	10^{14} - 10^{15}

* Refs. 378, 379, 381-387.

The one-component RTV silicone rubbers are mostly used in adhesive and sealant applications. Other uses include formed-in-place gasketing, protective coatings, and encapsulation; bonding properties are important. Many formulations provide self-bonding to most metals, glass, ceramics, concrete, and plastics. For example, bonds to aluminum with >1.38 MPa (200 psi) shear strength and 0.35 J/cm^2 (20 lbf/in.) tear strength are reported; good bonds are formed with copper and acrylic resins. Bonding can be improved by applying a primer to the substrate. These primers are solutions of reactive silanes or resins that dry (cure) on the substrate, leaving a modified silicone bondable surface. Bond strength develops as the RTV cure progresses and can require up to 2-3 weeks (362,388-391).

The two-component RTV silicone rubbers are available in a wide range of initial viscosities, from as low as an easily pourable $100\text{-mm}^2/\text{s}$ material to as high as the stiff pastelike materials of over $1,000,000 \text{ mm}^2/\text{s}$ at 25°C (383). Curing system, polymer molecular weight and structure, cross-link density, filler, and additives can be varied and combined, giving a group of products whose properties cover a wider range than that encompassed by the one-component products. The highest strength RTV rubbers are provided by two-component RTV technology. On the other hand, products that cure to a mere gel are also available (392). Unfilled resin-reinforced compositions can provide optical clarity (393,394). Polymers with phenyl, trifluoropropyl, cyanoethyl, or other substituents can be used with or in place of polydimethylsiloxanes for low temperature-, heat-, radiation-, and solvent-resistant elastomers (67,383,395).

The two-component RTV silicone rubbers do not require atmospheric moisture to trigger cure. Several different curing systems are employed, with different advantages. For example, the silanol-terminated silicone polymer is treated with alkoxy-functional silicon curing agents:

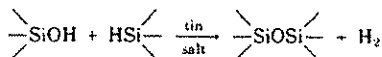


The catalyst is usually a tin salt. The product can be designed in such a way that the polymers and curing agent are in one package and the catalyst alone or the curing agent and the catalyst in the other. Cure is triggered by mixing the contents of the two packages. Fillers and additives are incorporated in the formulations according to the desired product properties (7,396).

In one example the polymers are mixed with filler and ethyl silicate as the curing agent. Dibutyl tin dilaurate catalyst is stirred in, and polymerization

begins immediately with the elimination of ethyl alcohol. The pot life and work life depend on temperature and catalyst type and concentration: pot life is a few hours at room temperature and can be prolonged by cooling. The time required to obtain a firm cure is approximately one day at room temperature and ca 1 h at 150°C (383). The cure rate is increased markedly with accelerators, such as 3-aminopropyltriethoxysilane (397).

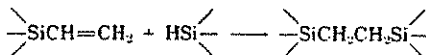
The reaction of silanol-terminated silicone polymers with hydride-functional siloxanes is another route to RTV two-component products. The hydrogen gas generated as by-product can be used for foaming.



When foaming is not desired, this type of product is usually restricted to thin films of RTV rubber (7).

Despite the commercial importance of products based on these RTV cure systems, little has been published concerning their chemistry. It has been shown that, in the RTV system involving silanols and ethyl silicate, ethanol evolves and siloxanes form; the reaction requires a tin compound initiator, which forms SiOSn compounds with ethyl silicate (398).

Hydrosilation curing gives two-component RTV rubbers without liberating a by-product. This cure system is based on the addition of silicon hydride to olefin. In practice, vinyl-functional silicone polymers are used with hydride-functional siloxanes as curing agent.



The reaction proceeds at room temperature in the presence of a catalyst, eg, chloroplatinic acid or another solubilized platinum compound. The hydrosilation cure of two-component RTV rubbers can be formulated in various ways. Fillers and additives are used according to the desired properties, but their character is restricted because of the sensitivity of platinum catalysts to poisoning. The catalyst is usually included with the vinyl-functional silicone polymers in the first package, and the hydride-functional siloxane curing agent, perhaps with additional vinyl polymers, in the second. The proportions used determine the ratio in which the two packages are mixed to give a cured elastomer with optimal properties. The pot life of these products is a few hours at room temperature (7,383,399).

Although in the other cure systems for RTV rubbers cross-links are established by the formation of new siloxane bonds by condensation reactions, this hydrosilation reaction creates ethylene bridges $\text{—Si—CH}_2\text{CH}_2\text{—Si—}$ between polymer chains. At room temperature, cure requires several days, but is usually run at higher temperatures (50–100°C). Control of the environment is important because the catalyst can be poisoned; water and alcohols react with Si—H in the presence of these catalysts: $\text{—SiH} + \text{H}_2\text{O} \longrightarrow \text{—SiOH} + \text{H}_2$. This reaction can also

be used to produce foamed rubber. Such materials, formulated for flame retardancy, are employed in wall construction to hinder the spread of fire.

The two-component RTV silicone rubbers are extensively used in encapsulating and molding applications, as well as for bonding, sealing, protective coatings, and electrical insulation. They afford longer work life and faster cures than the one-component products and are used in applications that require cure of thick sections. These cured RTV rubbers often do not adhere to other surfaces and are most suitable for fabricating flexible molds. They can be easily molded into various articles (340,383-385,388). Silicone elastomer emulsions made with hydrosilation-curing systems (latexes) are used for coatings (400).

The two-component RTV rubbers are less prone to self-bonding than the one-component materials; primers are applied where adhesion is needed. Lap-shear adhesion strengths exceeding 3.4 MPa (500 psi) have been reported on primed aluminum (389,390).

Batch equipment for RTV compounding includes vertical overlapping blade mixers with interchangeable bodies or cans, which can be lowered for product transfer or cleanout; they are called change-can mixers. Mixing cycles may be longer than in dough-mixer compounding since the lower viscosity polymers employed offer less resistance and delay the high shear necessary for deagglomeration of filler aggregates and good dispersion in the polymer. Compounding recipes differ from those for heat-cured rubber.

In one-component formulations that rely for cure on the reaction between a reactive cross-linking agent and atmospheric moisture, the ingredients must be thoroughly dried, or a drying step must be included in the compounding cycle. As more filler is added during compounding, the resistance to mixing tends to peak until "wetting-in" is reached. The moisture-sensitive cross-linking agent is usually added last; this step can be performed separately. When the uncatalyzed base compound and cross-linking agent are mixed, the effective viscosity sometimes passes through a maximum. As the early chemical interactions are resolved, the typical consistency is obtained. Allowance for elevated effective in-process viscosities must be made when mixing equipment is specified. Silica-reinforced uncatalyzed base compounds harden (develop structure) on storage, and the addition of catalyst should not be delayed.

Although formulations vary widely, a simple one-component acetoxysilane curing formulation might have the approximate composition given in Table 15. The silicone polymer may be a silanol-terminated polydimethylsiloxane with a viscosity of ca 10,000 mm²/s (=cSt), fumed silica is the reinforcing filler, and dibutyl tin dilaurate is the catalyst. Lower molecular weight silanol-functional fluids provide process aids. Such fluids have viscosity values of less than 200 mm²/s (=cSt) and may contain some branching; hydroxy group contents are between 0.1 and 8% (359).

For two-component formulations each part may contain varying proportions of filler and polymer. The second part contains the curing catalyst and possibly the cross-linking agent and pigments. By proper design of the compound, the proportions of first and second parts to be used may be adjusted for convenient handling and metering. (From 1 to 20 parts of the first part are typically used per part of the second.) Milling on a three-roll paint mill may be necessary to

Table 15. Acetoxysilane Curing Formulation

Component	Parts by weight
base	
silicone polymer	100
reinforcing filler	20
process aids	15
pigment	1
curing agent	
cross-linking methyltriacetoxysilane	5
catalyst	0.1

break down the last filler agglomerates, especially when sintered oxides or other hard fillers are used.

In continuous processing a devolatilizing extruder can be used to prepare RTV materials. The ingredients are incorporated at precise points in the production stream to obtain the desired degree of dispersion and chemical reaction. Base compounding and subsequent addition of catalyst for one-component formulations can be combined in one process. Special advantages are provided by systems that require unusually high shear mixing or that liberate substantial amounts of heat (401).

Continuous processing permits superior process control. A closed-loop process is illustrated in Figure 19. The feed rates of the ingredients can be monitored and adjusted to yield specific properties. The concentration of cross-linking agent, for example, can be continuously and automatically measured (402).

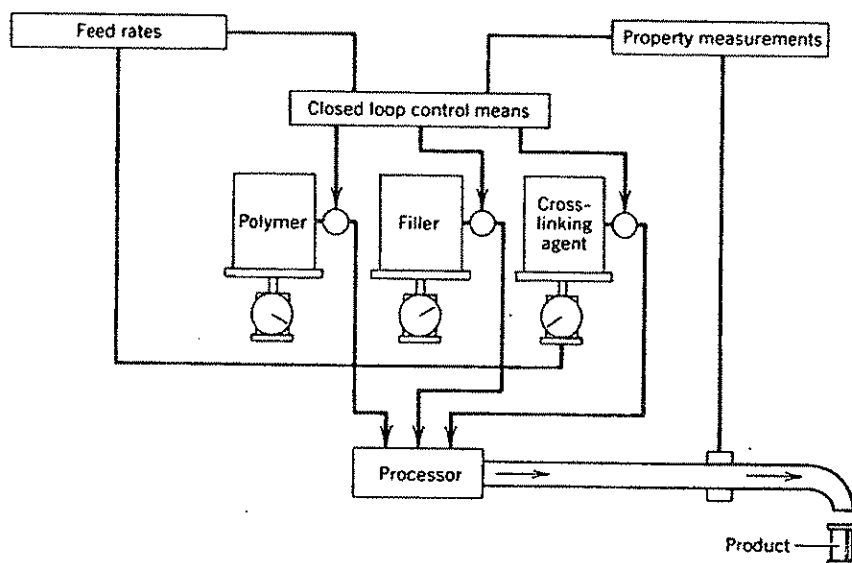


Fig. 19. Continuous one-component RTV processing. Adapted from Ref. 402.

The one-component RTV products are packaged in pails and drums with linings or seals to bar moisture. Many of these products are also packaged by automatic equipment into tubes and cartridges for dispensing by gun on assembly lines, in construction, or for home use.

Some two-component RTV products are sold as kits, in which the parts are formulated to afford the desired properties when used together. This is unnecessary when the second part contains only catalyst (383,385). Compounds that are packaged in hermetically sealed containers may be continuously deaerated by passing the compound as a thin film through an evacuated chamber. The two-component RTV products are packaged in cans, pails, and drums. Some curing agents are supplied in bottles or squeeze tubes.

New packaging materials and design innovations have made RTV products available in lighter, more economical, convenient containers. One Touch sealants from General Electric are easily dispensed from pressurized containers designed for consumer use, for example.

Heat-cured Rubbers. Many two-component RTV elastomers can be advantageously cured at 50–150°C, depending on the product and intended use, but RTV is characteristic. Hydrosilation-curing RTV compositions can be modified with inhibitors to become heat-curing systems. Some inhibitors are volatile vinyl or acetylenic compounds that are expelled at elevated temperatures, followed by cure. These volatile inhibitors may form vapor pockets that disrupt the integrity of the cured rubber and mar its surface. Examples include olefinic nitriles and acetylenic alcohols, which form complexes with the platinum catalysts that are ruptured by heat (280,403). Inhibitors such as triallyl isocyanurate release the catalyst at elevated temperatures, but are not volatile and are quickly incorporated into the cured elastomer (281). Such inhibited products are used in applications where long pot lives (10–1000 h), are needed after mixing the two packages and where the option of heat curing is available for a cure in less than 1 h, and often in minutes or seconds. Liquid injection molding, electronic potting, and coating operations are such applications.

Unlike RTV compositions, most heat-curing silicone rubbers are based on high molecular weight polymer gums. Gums, fillers, and additives are mixed in dough mixers or Banbury mills. Catalysts are added on water-cooled rubber mills, which can be used for the complete process in small-scale operations (67,404–406).

Silicone rubbers are commercially available as gums, filler-reinforced gums, dispersions, and uncatalyzed and catalyzed compounds; the last are ready for use. Dispersions or pastes are stirred with solvents such as xylene. The following types of gums are commercially available: general purpose (methyl and vinyl), high and low temperature (phenyl, methyl, and vinyl), low compression set (methyl and vinyl), low shrink (devolatilized), and solvent resistant (fluorosilicone); properties are shown in Table 16.

The tensile strength of cured dimethylsilicone rubber gum is only ca 0.34 MPa (50 psi). Finely divided silicas are used for reinforcement. Other common fillers include mined silica, titanium dioxide, calcium carbonate, and iron(III) oxide. Crystallizing segments incorporated into the polymer also serve as reinforcement. For example, block copolymers containing silphenylene segments, $-\{(\text{CH}_3)_2\text{SiC}_6\text{H}_4\text{Si}(\text{CH}_3)_2\text{O}\}_n-$, may have cured gum tensile strengths of 6.8–18.6 MPa (1000–2700 psi) (119).

Table 16. Properties of Silicone Gums^a

Type	Density d_4^{25} g/cm ³	T_g , °C	Williams plasticity ^b
CH ₃ (C ₆ H ₅)SiO	0.98	-123	95-125
CH ₃ (C ₆ H ₅) ₂ SiO	0.98	-113	135-180
CH ₃ (CF ₃ CH ₂ CH ₂)SiO	1.25	-65	

^a Refs. 319, 386, 387, and 407.^b ASTM D926.

Consistencies of uncured rubber mixtures range from a tough putty to a hard deformable plastic. Those containing reinforcing fillers tend to stiffen, ie, develop structure, on storage. Additives, such as water, diphenylsilanediol, dimethylpinacoxysilane, or silicone fluids, inhibit stiffening (353,408,409).

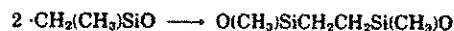
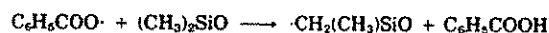
The properties of fabricated rubber depend on the gum, filler, catalyst, additives, and solvents and their proportions. A high filler content increases hardness and solvent resistance and reduces elongation. The properties also depend on the thoroughness of mixing and the degree of wetting of the filler by the gum. The properties change as cure progresses and are stabilized by devolatilization. They are affected by the environment and aging.

Before being used, silicone rubber mixtures are freshened. Catalyst is added, and the mixture is freshly milled on rubber mills until the components band into smooth continuous sheets that are easily worked. Specific or custom mixtures are prepared by suppliers for particular product applications; hundreds of formulations have been compounded. A formula is designed to achieve some special operating or processing requirement, and formulations are classified accordingly (Table 17) (352,386-388).

Bouncing putty is a mixture of polydimethylsiloxane polymer gum, boric acid, special additives, fillers, and plasticizers. It flows on slow application of pressure like a highly viscous liquid, but on shock it behaves like an elastic solid and may even shatter (410,411).

Silicone rubbers are cured by several mechanisms. For hydrosilation cure high molecular weight polymers (gums) with vinyl functionality are combined with fluid hydride-functional cross-linking agents. The catalyst, a soluble platinum compound, is added with an inhibitor to prevent cure initiation before heating (176). High strength and solvent-resistant products are based on this technology (412,413).

Silicone rubber is usually cured by heating the reinforced polymer with a free-radical generator, eg, benzoyl peroxide. The predominant mechanism for polydimethylsiloxane elastomers appears to be one in which hydrogen is removed from the methyl groups and the resulting free radicals couple to form Si-CH₂CH₂-Si bridges:



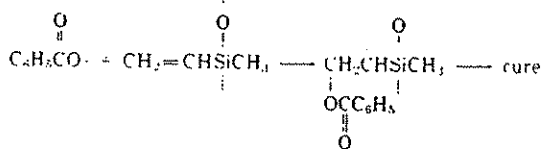
When the polymer contains vinyl groups (usually <1%), the peroxide radical

Table 17. Properties of Silicone Rubber Classes^a

Class	Hardness, durometer	Tensile strength, MPa ^b	Elongation, %	Compression set at 150°C for 22 h, %	Useful temperature range, °C		Tear strength, J/cm ²
					Minimum	Maximum	
general purpose:	40-80	4.8-7.0	100-400	15-50	-60	260	0.9
low compression set	50-80	4.8-7.0	80-400	10-15	-60	260	0.9
extreme low temperature	25-80	5.5-10.3	150-600	20-50	-100	260	3.1
extreme high temperature	40-80	4.8-7.6	200-500	10-40	-60	315	
wire and cable	50-80	4.1-10.3	100-500	20-50	-100	260	
solvent resistant	50-60	5.8-7.0	170-225	20-30	-68	232	1.3
high strength flame retardant	40-50	9.6-11.0	500-700				2.8-3.8

^a Refs. 352, 386-388.^b To convert MPa to psi, multiply by 145.^c To convert J/cm² to lb/in., multiply by 57.1.

fragment adds to the double bond to give a radical that leads to cure:



The vinyl-based cure does not usually generate a benzoic acid by-product, which catalyzes decomposition or rearrangement of the siloxane polymer; it functions with less peroxide and works with peroxides that do not abstract hydrogen from methyl groups, eg, 2,5-dimethyl-2,5-di(*t*-butylperoxy)hexane (67,339).

Benzoyl peroxide is most widely used for these cures. About 1.5–2 wt % is used for gums free of vinyl groups and ca 1 wt % for vinyl gums, based on the weight of gum; the curing temperature is ca 120°C. Bis(2,4-dichlorobenzoyl) peroxide, *t*-butyl peroxybenzoate, and dicumyl peroxide are used to obtain special effects. For example, bis(2,4-dichlorobenzoyl) peroxide permits rapid cure in air at 315°C without the development of porosity, which would be caused by the volatilization of lower boiling catalysts (342). Chlorobenzoyl peroxides give chlorobiphenyl by-products (275).

Cure is also effected by gamma or high energy electron radiation, which causes scission of all types of bonds, including Si—O; the important cure reactions are those involving Si—C and C—H. Hydrogen, methane, and ethane evolve, and bridges between chains are formed by recombination of the radicals generated. These bridges include Si—CH₂—Si, Si—Si, and perhaps Si—CH₂CH₂—Si (414). An absorbed dose of 770–1300 C/kg (3×10^6 to 5×10^6 roentgen) is required for effective cure; no acidic fragments remain in the polymer. Radiation cure can be used for thick sections, but high energy electrons penetrate to a depth of only a few millimeters (352).

Freshly mixed silicone rubber compounds are usually molded at 100–180°C and 5.5–10.3 MPa (800–1500 psi). Under these conditions thermal cure can be completed in minutes. The molds are usually lubricated with a 1–2 wt % aqueous solution of a household detergent. In the manufacture of insulated wire, rods, channels, tubing, and similar products, the compounds are extruded in standard rubber-extrusion equipment. The extruded rubber is heated briefly to set its properties; hot-air vulcanization at 300–450°C or steam at 0.28–0.70 MPa (40–100 psi) for several minutes is sufficient. Final properties can be developed by oven curing or by continuous steam vulcanization.

For coating silicone rubber on a fabric, eg, glass cloth, a dispersion in a solvent is employed. The cloth may be dip-coated and dried and cured in heated towers. It may also be calendered with high penetration, soft silicone stocks on standard three- and four-roll calenders. Ducts and hoses can be built up from dip-coated or calendered cloth, and complex structures can be formed on mandrels, followed by extrusion or by wrapping and curing to produce large ducts. Silicone rubber sponges are made with the help of nitrogen blowing agents, which produce a closed-cell structure; densities of foam or sponge are between 0.4 and 1.0 g/cm³.

For bonding silicone rubber to other materials, eg, metals, ceramics, or plastics, primers are used, including silicate esters, silicone pastes, silicone resins.

Chapter 12
MOLD FINISHING *continued*



MOLD CONSTRUCTION TECHNIQUES

As previously mentioned, final part geometry generally influences the mold-construction technique. This section discusses several of the most-common construction methods.

Milled Block

In this construction technique, the mold cavity is machined directly into a metal block. Although it may be more costly, a milled-block mold gives the most accurate representation of the part, does not show

lines where the mold parts meet, and incorporates cooling lines easily; however, they are more difficult to modify.

Structural Components

Milled metal plates are joined with screws or pins, or welded in this construction technique. Joined plate and bar is the method of choice for large, flat parts.

Cast

Widely used in mold making, cast molds are relatively inexpensive. They make excellent molds and are used particularly for curved parts. Steel molds are not normally cast. Surface porosity, often just under the skin, can cause difficulties when polishing cast aluminum molds. To make a mold casting, a positive pattern with a predetermined parting line is made. This pattern is then cast. Afterwards, the surface is conditioned to remove bubbles and imperfections. Cooling lines can be cast into the mold.

Extruded Aluminum Profiles

Used for both solid and foamed systems, extruded profiles find special application in building inexpensive molds for profile geometries such as window frames or door sashings.

Nickel Plating

Nickel plating can be formed either electrolytically or by electroless deposition. In this latter technique, a 0.04- to 0.08-inch layer of nickel is deposited on a positive pattern, with a 3/8- to 1/2-inch copper backup layer electrolytically deposited onto the nickel. Cooling lines can also be plated onto this backup layer.

SURFACE TREATMENTS FOR MOLDS

Because RIM polyurethane systems reproduce fine surface details, the type of finish on a mold surface is critical. Consider using plastic-industry standards such as the SPI-SPE Mold Finish Comparison Kit, available from the Society of Plastics Industry, as a guideline.

Chrome and nickel plating, excellent surface treatments for molds, improve the mold's scratch resistance and reduce necessary demolding forces. Chrome plating gives better results. Before plating any mold surface, closely examine it to ensure that it is smooth and nonporous.

Other treatments such as Teflon coating or a nickel-polymer coating are used to improve mold release properties. Surface hardening methods — such as nitride — can minimize minor damage and the effects of abuse during production operations.

Depending upon your part's surface specifications, consider using the following finishes:

- No. 2 Grit (#15 micron range)
- No. 3 320 Emery Cloth
- No. 4 280 Stone

For cosmetic surfaces, consider using a finish between No. 2 and 3; for noncosmetic surfaces, a finish between 3 and 4 should suffice.

TEXTURES AND FINISHES

Lettering, textures, and graphics can be molded into a part. Typically these visual elements are milled into the mold resulting in a raised appearance on the finished part. For large areas of fine text, consider using decals.

Textures enlarge the effective surface area, requiring increased demolding forces. Surfaces parallel to the direction of draw have lower limits on texture depth.

Nickel shells offer high surface hardness and good release characteristics for high-quality surface reproductions of textures, such as leather or wood grain.

Photo-etching and mechanical texturing offer a wide variety of finishes. In photo-etching, chemicals etch mold surfaces in a given pattern. Some mold makers have examples with different textures to help you select one. In mechanical texturing, small metal balls are placed in the mold, which is then shaken, to achieve a pebble finish.

Before applying any texture to a mold surface, ensure that the mold is to final dimensions, because these dimensions cannot be changed after texturizing. Textures in molds must be very accurate, as the parts cannot be retouched after molding. These molds are very sensitive to nicks and scratches, requiring special care during demolding.

Chapter 13

TECHNICAL SUPPORT

**HEALTH AND SAFETY
INFORMATION**

Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling Bayer thermosetting resins mentioned in this publication. Before working with any of these products, you must read and become familiar with the available information on their hazards, proper use, and handling. This cannot be overemphasized. Information is available in several forms, e.g., material safety data sheets and product labels. Consult your local Bayer representative or contact the Product Safety Manager for Polymers Division products in Pittsburgh, PA.

**DESIGN AND ENGINEERING
EXPERTISE**

To get material selection and/or design assistance, just write or call your Bayer representative in the regional offices listed on the back cover of this brochure. To best help you, we will need to know the following information:

- Physical description of your part(s) and engineering drawings, if possible
- Current material being used
- Service requirements, such as mechanical stress and/or strain, peak and continual service temperature, types and concentrations of chemicals to which the part(s) may be exposed, stiffness required to support the part itself or another item, impact resistance, and assembly techniques
- Applicable government or regulatory agency test standards
- Tolerances that must be held in the functioning environment of the part(s)
- Any other restrictive factors or pertinent information of which we should be aware

Upon request, Bayer will furnish such technical advice or assistance it deems to be appropriate in reference to your use of our products. It is expressly understood and agreed that because all such technical advice or assistance is rendered without compensation and is based upon information believed to be reliable, the customer assumes and hereby releases Bayer from all liability and obligation for any advice or assistance given or results obtained. Moreover, it is your responsibility to conduct end-use testing and to otherwise determine to your own satisfaction whether Bayer's products and information are suitable for your intended uses and applications.

TECHNICAL SUPPORT

We provide our customers with design and engineering information in several ways: Applications and processing advice, available by phone, at 412 777-2000; processing assistance, through a nationwide network or regional field technical service representative (see list on back cover); technical product literature; and periodic presentations and seminars. The types of expertise you can obtain from Bayer include those listed in this section.

Design Review Assistance

- Concept development
- Product/part review
- Mold design review
- Part failure analysis
- Finite element stress analysis
- Mold filling analysis
- Experimental stress analysis
- Shrinkage and warpage analysis

Application Development Assistance

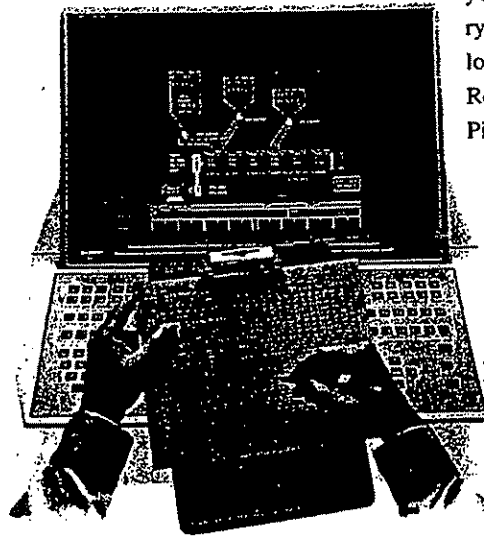
- Product development
- Part cost estimates
- Color matching
- Prototyping
- Material selection
- Molding trials
- Physical testing
- Secondary operation advice

Product Support Assistance

- On-site processing audits
- Start-up assistance
- On-time material delivery
- Troubleshooting
- Processing/SPC Seminars
- Productivity audits

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Some of the end uses of the products described in this publication must comply with applicable regulations, such as the FDA, USDA, NSF, and CPSC. If you have any questions on the regulatory status of these products, contact your local Bayer representative or the Regulatory Affairs Manager in Pittsburgh, PA.



Chapter 13

TECHNICAL SUPPORT *continued***RIM PLASTICS RECYCLING**

Polyurethanes are now being recycled. Recycled polyurethanes have practical uses, like housings for electronic equipment and exterior body parts for transportation vehicles.

- **Regrinding**—This technology allows for a "second life" for many types of polyurethane parts such as business machines and bumpers, which are then ground into a granulate or powder for use as a filler.
- **Adhesive Pressing**—Polyurethane granulate is surface treated with a binder, then cured under heat and pressure. The resulting materials can be reinforced and molded.

- **Compression Molding**—This technique allows for 100% reuse of RIM polyurethane elastomers in which no virgin material needs to be added. Can retain up to 50% of tensile properties.

- **Energy Recovery**—Technology exists to pyrolyze polyurethane polymers cleanly, and the combustion products can meet EPA standards. One pound of RIM polyurethane contains between 12,000 and 15,000 BTUs, about the same energy potential as oil or coal.

- **Injection Molding**—This process is suitable for composite components, such as instrument panels that contain a thermoplastic support, foam, and decorative skin. The entire module can be ground and injection molded.

- **Glycolysis**—This is a chemical recycling process in which the polymer is broken down into a mixture of liquid polyols. Many different kinds of polyurethane parts can be used.

Polyurethanes. They do a world of good when you use them. And when you reuse them.

FOR MORE INFORMATION

The data presented in this brochure are for general information only. They are approximate values and do not necessarily represent the performance of any of our materials in your specific application. For more detailed information, contact Polymer Marketing Communications at 412 777-2000, or your nearest district office.

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Quick Design Reference Guide for RIM Materials

Polyurethanes

	Elastomers	Rigid RIM			Composites	
Parameters	Solid Bayflex System (Unfilled)	Foamed Baydur System	Solid Baydur GS System	Solid PRISM System (Thin-Walled)	Foamed Baydur STR/F System	Solid Baydur STR/C System

Part Design

0 Wall Thickness (in)	0.2 - 1.0	0.2 - 1.5	0.25 - 1.0	0.125 - 0.9	0.25 - 0.5	0.3 - 0.15
Rib Thickness, at Root ^a	0.75t	t	t	0.75t	Use box beam or corrugation	Use box beam or corrugation
Drain (degrees) This is function of Part Draw or Depth	0.5 min. 0.25/inch greater than 1/16 inch of draw	0.5 min. 0.25/inch greater than 1/16 inch of draw	0.5 min. 0.25/inch greater than 1/16 inch of draw	0.5 min. 0.25/inch greater than 1/16 inch of draw	1.0 min.	1.0 min.
Molded Holes/Slots	Yes	Yes	Yes	Yes	No	No
Undercuts	Yes Undercuts	Use side pull or removable insert	Use side pull or removable insert	Use side pull or removable insert	No	No
Snap Fits	Possible	Possible	Possible	Possible	No	No
Flats (inner Radius) (in)	1/16	1/8	1/8	1/16	1/8	1/8

Finishing

Best Surface	Class A	Class A	N/A	Class A	No Class A Use texture	Class A with veil
Screw Assembly	Use bolt & nut ^b	Thread cuts skin	Thread cutting	Thread cutting	Thread cutting	Thread cutting

Mold Design and Processing Parameters

Material/ Construction	Metal Pattern (300-400 in. 600-800 in.)	Metal Pattern (300-400 in. 600-800 in.)	Metal Pattern (300-400 in. 600-800 in.)	Metal Pattern (300-400 in. 600-800 in.)	Steel	Steel
Preferred Gating	Fan	Dam	Dam	Dam	Center/Direct	Center/Direct
Shot Time (sec)	30-60	30-60	15	30-60	5	15
Mold Pressure (psi)	100	100	100	100	200	200
Mold Temperature (°F)	100-150	100-150	100-150	100-150	100-150	100-150

Physical Properties

Flexural Modulus (psi)	5,000 - 10,000	3,000 - 240,000	120,000 - 90,000	270,000 - 310,000	150,000 - 750,000	150,000 - 2,000,000
Part Density (lb/in ³)	60 - 65	15 - 55	63 - 68	61 - 67	20 - 40	90 - 110
Flexural Strength (psi)	N/A	3,000 - 12,000	3,000 - 7,700	3,000 - 10,800	3,500 - 17,000	50,000
Tensile Strength (psi)	1,900 - 4,000	1,000 - 4,800	3,600 - 5,300	5,500 - 6,600	2,500 - 9,000	26,000
Elongation at Break (%)	100 - 350	3 - 10	13 - 23	11 - 12	2 - 25	55
DTUL at 66 psi (°F)	N/A	160 - 212	140 - 215	190 - 205	205	400
Hardness (Shore D)	30 - 69	30 - 31	70 - 75	70 - 75	70 - 70	70 - 70
% Reinforcement	0 - 25	N/A	N/A	N/A	20 (mat)	55 (mat)

^aRoot includes both radii. ^bCan also screw through to metal substrate.^cLonger shot times are possible with a Bayflex XGT system, which has an extended gel time.



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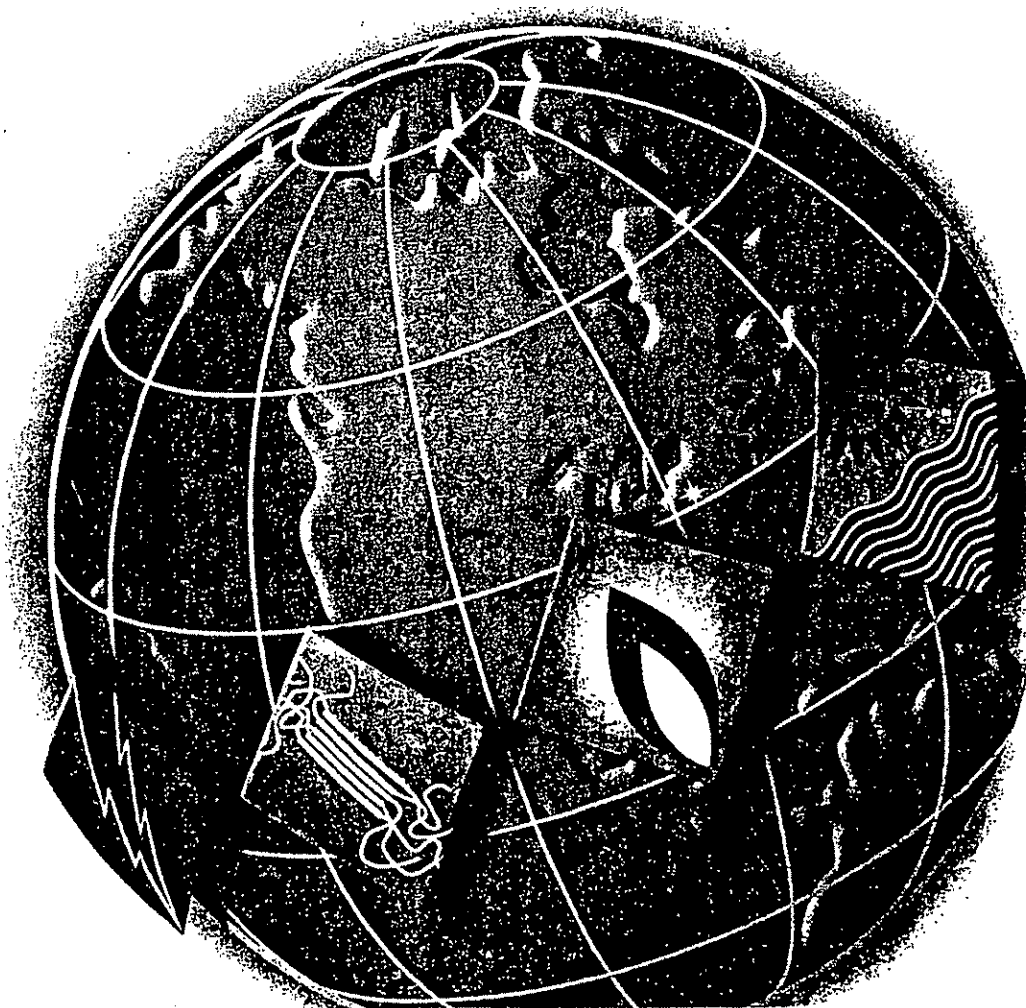


Engineering Polymers

Properties Guide

THERMOPLASTICS
AND
POLYURETHANES

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Thermoplastics from Bayer

The Polymers Division of Bayer Corporation supplies engineering thermoplastics and polyurethanes, technology, and equipment for a wide range of applications and industries.

Thermoplastics

The Plastics Department offers an extensive range of engineering thermoplastic resins and specialty plastics. In addition to the products listed in this brochure, polycarbonate films and thermoplastic urethane films are also available.

For information, please call
1-800-622-6004.

Products	Features
MAKROLON® Polycarbonate Pages 8-11	Glass-like transparency Outstanding impact strength Good thermal resistance Excellent dimensional stability Good electrical properties
APEC® High-Heat Polycarbonate Page 11	Glass-like transparency High deflection temperature under load High impact strength Excellent dimensional stability
BAYBLEND® and TRIAX® Polycarbonate/ABS Blend Pages 12-13	Good impact resistance even at low temperatures Rigidity and dimensional stability Easy processing Good color stability to indoor lighting Good thermal stability
MAKROBLEND® Polycarbonate Blend Pages 14-15	Good chemical resistance Excellent impact resistance even at low temperatures Good abrasion resistance Good processibility and thermal stability Rigidity and dimensional stability
TRIAx® Polyamide/ABS Blend Page 15	High impact strength Excellent abrasion characteristics Good chemical resistance and fatigue performance State-of-the-art blending technology Excellent processing characteristics
LUSTRAN® ABS Pages 16-17	Toughness, strength, and rigidity Heat and chemical resistance Dimensional stability and creep resistance Good surface appearance Good processibility

Thermoplastics from Bayer

Grades	Markets and Applications ^a
General-Purpose High-Productivity Impact-Modified Glass-Reinforced Flame-Retardant Structural Foam Extrusion Medical Optical Lighting Automotive Lens	Automotive and Transportation: forward and rear lighting components, instrument panels, aircraft canopies Building and Construction: extrusion resin for monolayer and structured sheet, profiles Business Machines: computer and printer housings, sight windows Consumer: power tool housings, food storage containers, appliances, sporting goods Electrical/Electronic: electric meter covers, telephone components, lighting diffusers and lenses ^b Medical: diagnostic, cardiovascular and intravenous devices; drug delivery systems; packaging Optical: lenses for prescription eyewear, sunwear, industrial safety glasses and specialty eye protection Optical Memory: audio and video compact discs, data storage discs Packaging: bottles, film
General-Purpose Flame-Retardant Medical	Automotive and Transportation: reflectors, lenses, and light pipes for interior and exterior lighting Consumer: steam iron water tanks, hair dryer components, microwave oven doors, gas range controls and ignition switches Electrical/Electronic: fuses, switch housings; lighting reflectors, diffusers and lenses Industrial/Mechanical: emergency equipment, face shields, indicator lenses ^b Medical: packaging, surgical lighting, autoclavable devices
General-Purpose High-Productivity Glass-Reinforced Flame-Retardant Structural Foam Extrusion and Blow Molding Plating	Automotive: interior and exterior parts, wheel covers, instrument panels Business Machines: computer, monitor and printer housings; general office equipment Consumer: household appliances, smoke detectors, lawn and garden equipment Electrical/Electronic: modular plugs, wiring devices
Impact-Modified Glass-Reinforced Flame-Retardant ^c FDA-Compliant Transparent	Automotive: body panels, bumpers, interior switches, exterior mirror housings Consumer: appliances, food trays, household cleaning equipment, lawn and garden equipment, sporting goods, telecommunications equipment Electrical/Electronic: connectors, electrical housings, interrupters, switch housings Industrial/Mechanical: meter housings, pump housings, agricultural equipment
General-Purpose Glass-Reinforced Extrusion	Automotive: interior functional components, fasteners, housings and shrouds Consumer: appliances, lawn and garden equipment, power tools, sporting goods
Molding High-Gloss Low-Gloss High-Impact High-Heat Extrusion Medical Clear	Automotive: interior and exterior trim, pillar posts, consoles, scuff plates, map pockets Business Machines: keyboard keys, computer housings and bezels Consumer: housewares, small appliance housings, floor care components, lawn and garden appliances, power tool housings, toys, telecommunications equipment, consumer electronics Industrial/Mechanical: drain, waste and vent pipe and fittings ^b Medical: drug delivery systems, diagnostic equipment and instruments, test kits Packaging: cosmetic containers Sheet and Profile: custom extruded products

^a As with any product, use of a particular resin in a given application must be tested (including field testing, etc.) in advance by the user to determine suitability.

^b Please refer to Bayer Corporation guidelines for medical application of Bayer products on pages 4-5.

^c Makrolon DP4-1370 resin (natural color) can be used for food-contact applications except for those in which the temperature exceeds 250°F and the food contains more than 50% alcohol. Since color possibilities for food-contact applications are limited, please contact your Bayer representative for information on available colors and their limitations.

Thermoplastics from Bayer

(continued)

Thermoplastics

The Plastics Department offers an extensive range of engineering thermoplastic resins and specialty plastics. In addition to the products listed in this brochure, polycarbonate films and thermoplastic urethane films are also available.

For information, please call
1-800-622-6004.

Products	Features
LUSTRAN® SAN Page 18	Glass-like clarity Strength and rigidity Excellent chemical resistance Heat and abrasion resistance Easy processing
CADON® SMA Pages 18-19	High heat resistance Impact strength Rigidity Good chemical resistance
CENTREX® ASA, AES and ASA/AES Weatherable Polymers Page 19	Toughness and durability Resistance to fading and cracking from sunlight and temperature extremes Resistance to road chemicals Light weight
DURETHAN® Polyamide 6 Pages 20-23	High strength, rigidity and hardness Excellent toughness and impact resistance High dynamic fatigue resistance Excellent abrasion and chemical resistance High heat resistance in reinforced grades Good electrical insulating properties
TEXIN® and DESMOPAN® Thermoplastic Polyurethane Pages 24-25	Excellent abrasion resistance Excellent resistance to fuels and oils High tensile and tear strength High elasticity and resilience Good vibration dampening Shore hardness range from 85A to 75D

^a As with any product, use of a particular resin in a given application must be tested (including field testing, etc.) in advance by the user to determine suitability.

^b Please refer to Bayer Corporation guidelines listed below for medical application of Bayer products.

Bayer Corporation Guidelines for Medical Application of Bayer Products

1. All Bayer resins, films, etc. [hereinafter "Product(s)"] designated as "medical-grade" have met the requirements of the FDA-Modified ISO 10993, Part I "Biological Evaluation of Medical Devices" tests with human tissue contact time of 30 days or less. ONLY THESE PRODUCTS MAY BE CONSIDERED CANDIDATES FOR APPLICATIONS REQUIRING BIOCOMPATIBILITY. No "medical-grade" Product will be available for sale until successful completion of testing.
2. Regrind resins must not be used in medical applications requiring biocompatibility.
3. It is the responsibility of the medical device, biological product or pharmaceutical manufacturer ("Manufacturer") to determine the suitability of all component parts and raw materials, including any Bayer Product, used in its final product in order to ensure safety and compliance with FDA requirements. This determination must include, as applicable, testing for suitability as an implant device and suitability as to contact with and/or storage of human tissue and liquids including, without limitation, medication, blood or other bodily fluids.
4. Under no circumstances may any Bayer Product be used in any cosmetic, reconstructive or reproductive implant applications. Nor may any Bayer Product be used in any other bodily implant applications, or any applications involving contact with or storage of human tissue, blood or other bodily fluids, for greater than 30 days, based on the FDA-Modified ISO 10993 tests. Furthermore, for aromatic grades of Texin resins, such longer-term uses are not permissible also because possible hydrolysis of solid polyurethane may produce aromatic amines, such as methylene dianiline (MDA).

Thermoplastics from Bayer

(continued)

Grades	Markets and Applications ^a
General-Purpose High-Clarity High-Performance	Consumer: food and beverage containers, dinnerware, housewares, appliances, interior refrigerator components, toys Industrial/Mechanical: fan blades, filter housings ^b Medical: tubing connectors and valves, labware, urine bottles Packaging: cosmetic containers and displays
High-Heat Glass-Reinforced Extrusion	Automotive: interior and exterior trim, instrument panels Consumer: appliances, power tools Industrial/Mechanical: machinery parts
General-Purpose Gloss-Retention Extrusion	Automotive: interior trim, exterior and aftermarket parts Consumer: lawn and garden tractor components; boat and marine accessory parts; spa shells; swimming pool steps, covers and filter housings; golf accessories Miscellaneous: outdoor signs Specialty Transportation: recreational vehicle exterior parts
Unreinforced Impact-Modified Glass-Reinforced Mineral-Reinforced Mineral/Glass-Reinforced Reduced-Moisture and Impact-Modified versions of Glass-Reinforced and Mineral-Reinforced grades are available. Film grades available (not listed in table).	Automotive: interior and exterior parts, door handles, mirrors, wheel covers Consumer: furniture, lawn and garden equipment, power tool housings, sporting goods Electrical/Electronic: wiring devices, switch housings, fuse holders Industrial/Mechanical: pumps, fans, pneumatic tools, housings Packaging: film for packaging of food, chemicals, medical and industrial goods
Polyester Polyether Polyurethane/Polycarbonate Blends Medical Extrusion	Automotive: cams, gears, mechanical parts, exterior applications, side body molding Building and Construction: extrusion resins for film and sheet Consumer: golf balls, ski goggle frames, shoe components, ski boots Industrial/Mechanical: mine screens, animal identification tags, hydraulic seals, hoses, caster wheels, grain buckets ^b Medical: diagnostic devices, tubing and catheters, connectors

- The suitability of a Bayer Product in a given end-use environment is dependent upon various conditions including, without limitation, chemical compatibility, temperature, part design, sterilization method, residual stresses or external loads. It is the responsibility of the Manufacturer to evaluate its final product under actual end-use requirements and to adequately advise and warn purchasers and users thereof.
- Single-use medical devices made from a Bayer Product are not suitable for multiple uses. If the medical device is designed for multiple uses, it is the responsibility of the Manufacturer to determine the appropriate number of permissible uses by evaluating the device under actual sterilization and end-use conditions and to adequately advise and warn purchasers and users thereof.
- The sterilization method and the number of sterilization cycles a medical device made from a Bayer Product can withstand will vary depending upon type/grade of Product, part design, processing parameters, sterilization temperature and chemical environment. Therefore, the Manufacturer must evaluate each device to determine the sterilization method and the number of permissible sterilization cycles appropriate for actual end-use requirements and must adequately advise and warn purchasers and users thereof.
- Parts molded or extruded from Texin resins are sterilizable using ethylene oxide, radiation or dry heat. Steam autoclaving and boiling water techniques are possible only with select aliphatic grades of Texin resin. These sterilization methods must not be used with aromatic grades of Texin resin because possible hydrolysis may produce aromatic amines, such as methylene dianiline (MDA).

Polyurethanes from Bayer

Polyurethanes

The Polymers Division produces polyurethane raw materials and systems for the automotive, appliance, construction and furniture industries, as well as many other markets, such as consumer, industrial/mechanical, medical, and specialty transportation. In addition to the specialty systems listed in this brochure, the Polyurethanes Department offers integral skin foams; elastomeric, microcellular soling systems for the production of shoe soles; and semirigid, high-resilience and energy-absorbing foams. Moreover, a full range of raw materials and additives include diphenylmethylene diisocyanate (MDI), toluene diisocyanate (TDI), and polyols. A complete line of equipment for polyurethane processing is produced by the division's Hennecke Machinery Group.

For information, please call
1-800-622-6004.

Products	Features
BAYDUR® Structural Foam Polyurethane RIM Systems <small>Pages 26-27</small>	Two-component, MDI-based liquid systems Large-part moldability Stiffness High-gloss finish and excellent surface quality In-mold coating Used for thick- and thin-wall parts
BAYDUR® SFR Composite Polyurethane RIM Systems <small>Page 27</small>	Two-component, MDI-based liquid systems Light weight High strength-to-weight ratio Excellent adhesion to fabric and vinyl
BAYDUR® STR Composite Polyurethane SRIM Systems <small>Page 27</small>	Two-component, MDI-based liquid systems Exceptional impact strength and stiffness Used for large structural parts
BAYDUR® GS Solid Polyurethane RIM Systems <small>Page 27</small>	Two-component, MDI-based liquid systems Excellent chemical resistance Stiffness Large-part moldability
PRISM® Solid Polyurethane RIM Systems <small>Page 27</small>	Two-component, MDI-based liquid systems Stiffness and high strength-to-weight ratio Good heat deflection temperature Excellent surface quality
BAYFLEX® Elastomeric Polyurethane RIM Systems <small>Pages 28-29</small>	Two-component, MDI-based liquid systems Large-part moldability Wide range of flexural moduli Superior impact strength Excellent surface quality and in-mold coating
BAYTEC® SPR Elastomeric and Structural Polyurethane Spray Systems <small>Page 30</small>	Two-component, MDI-based liquid spray systems Low-viscosity, solvent-free liquids (negligible VOCs) Used for structural parts or elastic membranes Good adhesion to substrates Fast cure times for ease in building laminates
BAYTEC® RTM Polyurethane Systems for Resin Transfer Molding <small>Page 30</small>	Two-component, MDI-based liquid systems Low-viscosity, solvent-free liquids (negligible VOCs) Outstanding impact resistance at high and low temperatures, with and without glass Fast reaction times and high flexural modulus
BAYTEC® Polyurethane Prepolymers for Cast Elastomers <small>Page 31</small>	MDI-based prepolymers Dynamic load-bearing ability Outstanding resilience and tear resistance Corrosion and abrasion resistance Flexible over a wide temperature range

Polyurethanes from Bayer

Grades	Markets and Applications ^a
General-Purpose Flame-Retardant	Agricultural/Construction Equipment: tractor cab roofs and consoles Automotive: aftermarket spoilers Construction: window and door frames Consumer: speaker housings, snow and water skis Electrical/Electronic: instrumentation and equipment housings, Nema 1 and 12 enclosures, telecommunications equipment Medical: analytical and diagnostic equipment housings Specialty Transportation: interior components for heavy trucks (Class 8)
Low-Density	Automotive: interior door panels, interior trim, sunshades
Low-Density High-Density	Automotive: bumper beams, inner door panels, interior trim, instrument panels, rear package trays, seat backs, seat pans
General-Purpose	Industrial/Mechanical: pump housings, underground applications (concrete and cast iron replacement) Telecommunications: utility boxes
General-Purpose Flame-Retardant	Electrical/Electronic: telecommunications equipment, instrumentation and equipment housings Medical: analytical and diagnostic equipment housings, laboratory instrumentation
Unfilled Glass-Filled Mineral/Microsphere-Filled	Agricultural/Construction Equipment: hay conditioning rollers, tractor body panels and door frames Automotive: fascias, body panels, window encapsulation, aftermarket restyling packages Specialty Transportation: heavy-duty truck bumpers, snowmobile hoods, work vehicles
Elastomeric Structural	Automotive: aftermarket restyling packages Consumer: on-deck marine accessories, spas and bathtubs Industrial/Mechanical: industrial liners, dump truck liners, containers, agricultural parts Miscellaneous: protection for wood, metal, and concrete
General-Purpose	Automotive: aftermarket restyling packages Consumer: marine accessories, radar dishes Industrial/Mechanical: pump housings, valve bodies, fan blades Specialty Transportation: components for heavy trucks, recreational vehicles, tractors, and construction vehicles
Polyester Poly(tetramethylene ether) glycol Poly(propylene ether) glycol	Industrial/Mechanical: tires and wheels, rolls, hydrocyclones, pipeline pigs, seals and gaskets, gears and sprockets, die-cut pads and chopper cots, belts, liners, classifier screens, conveyor belt scrapers, shock absorbers

^a As with any product, use of a particular polyurethane system in a given application must be tested (including field testing, etc.) in advance by the user to determine suitability.

Bayflex®
Polyurethane Elastomeric RIM

*Slits
Fabrication*

POLYURETHANES			MP-5000	MP-10000	110 RIM-Lite	110-25 IMR	110-50	
Typical Physical Properties*			Unfilled ¹	Unfilled	13% Mineral ²	Unfilled	Unfilled	15% Mineral ³
GENERAL								
Specific Gravity	D 792		1.1	1.1	0.95	0.98	1.04	1.15
Density	D 1622	lb/ft. ³	68.7	68.7	59.3	61.2	64.9	71.8
Thickness		in	0.118	0.118	0.150	0.125	0.125	0.125
Shore Hardness	D 2240 (Bayer)	A or D	82 A	90 A		50 D	58 D	60 D
Mold Shrinkage	(Bayer)	%	1.25	1.42	0.6	1.3	1.3	0.6
Water Immersion, Length Increase	(Bayer)	in/in	0.015	0.014		0.008	0.006	0.002
Water Absorption:		%						
24 Hours			3.3	3.3				
240 Hours			5.0	5.0		2.8	2.8	2.6
MECHANICAL								
Tensile Strength, Ultimate	D 638/D 412	lb/in ²	1,900	2,200	2,300	3,000	3,500	3,300
Elongation at Break	D 638/D 412	%	360	300	90	260	250	140
Flexural Modulus:	D 790							
149°F		lb/in ²	4,000	7,900			38,000	111,000
73°F		lb/in ²	5,000	10,000	71,000	25,000	52,000	125,000
-22°F		lb/in ²	14,500	23,600		350	115,000	250,000
Tear Strength, Die C	D 624	lb/in	230	240	400		450	640
Impact Strength:	D 256					8	11	3
Notched Izod		ft-lb/in						8
THERMAL								
Heat Sag:	D 3769							
6-in Overhang, 1 hr at 250°F		in			0.43	0.51	0.60	0.28
4-in Overhang, 1 hr at 250°F		in					0.36	0.27
Coefficient of Linear Thermal Expansion	D 696	in/in/°F	53 E-06	53 E-06			61 E-06	27 E-06
								44 E-06

* These items are provided as general information only. They are approximate values and are not part of the product specifications.

¹ 10% calcium silicate and 3% glass microspheres.

² RRIMGLOS 10013 (RRIMGLOS is a trademark of NYCO Minerals, Inc.).

³ Milled glass fiber, OCF 737, 1/16 inch.

⁴ Calcium silicate.

Note 1

All directional properties are listed parallel to flow.

Note 2

IMR: Internal Mold Release.

RIM: Reaction Injection Molding.

XGT: Extended Gel Time.

*First RIM ball
used this
12-17-97*

Bayflex®

Polyurethane Elastomeric RIM (continued)

110-80		160		XGT-16	XGT-50	XGT-80		XGT-100		XGT-140
Unfilled	15% Glass*	15% Mineral*	20% Mineral*	Unfilled	Unfilled	Unfilled	15% Glass*	Unfilled	15% Glass*	Unfilled
1.04 64.9 0.125	1.14 71.2 0.125	1.18 73.7 0.150	1.23 76.8 0.150	1.04 64.9 0.125 45 D 0.85	1.04 64.9 0.125 55 D 0.85	1.04 64.9 0.125 65 D 0.85	1.15 71.8 0.125 70 D 0.6	1.04 64.9 0.125 69 D 0.85	1.15 71.8 0.125 73 D 0.6	1.04 64.9 0.125 71 D 0.85
1.3	0.7		0.55-0.65							
3,500 135	3,200 75	4,100 150	3,900 130	2,400 250	3,500 200	3,700 150	3,800 75	4,000 140	4,100 50	4,200 80
51,000 80,000 200,000 470	100,000 150,000 275,000 600	183,000 580	195,000 630	16,000 450	18,000 50,000 105,000 530	33,000 83,000 180,000 630	78,000 170,000 280,000 650	45,000 100,000 220,000 670	95,000 210,000 400,000 680	50,000 140,000 260,000 700
5	3	2.8	3.2		12.5	12	5	7	4	4.5
0.31 61 E-06	0.16 28 E-06	0.20	0.05		0.67 61 E-06	0.59 61 E-06	0.39 31 E-06	0.59 61 E-06	0.43 28 E-06	0.59 61 E-06

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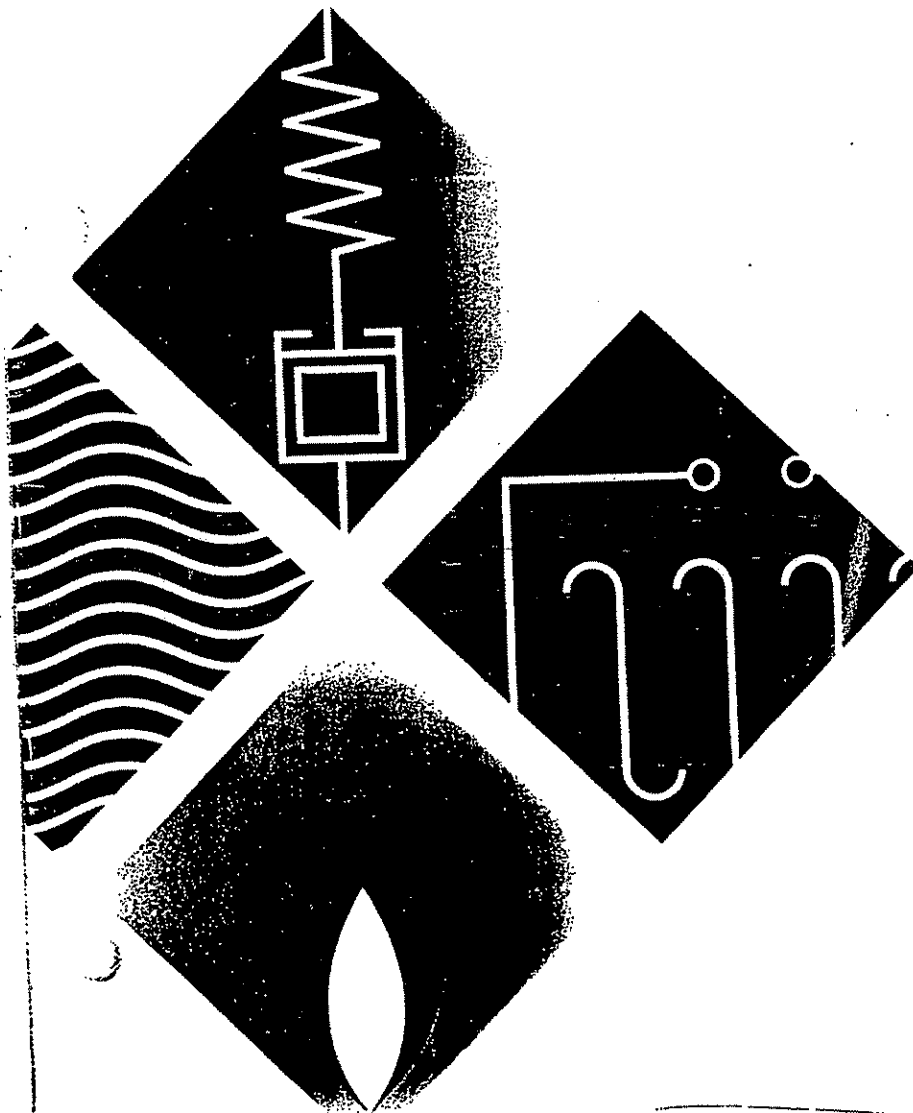
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Engineering Polymers

Properties Guide

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*Thermoplastics
and
Thermosets*

ENGINEERING THERMOPLASTICS BY MILES

The Polymers Division of Miles* supplies thermoplastic and thermoset polymers, technology, and equipment for a wide range of applications and industries.

Thermoplastics

The Plastics Department offers an extensive range of engineering thermoplastic resins and specialty plastics. In addition to the products listed in this brochure, polycarbonate films and thermoplastic urethane films are also available.

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Products	Features
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APEC High-Heat Polycarbonate Page 9	Glass-like transparency High deflection temperature under load High impact strength Excellent dimensional stability
BAYBLEND Polycarbonate/ABS Blend Pages 10-11	Good impact resistance even at low temperatures Rigidity and dimensional stability Easy processing Good color stability to indoor lighting Good thermal stability
MAKROBLEND Polycarbonate Blend Pages 12-13	Good chemical resistance Excellent impact resistance even at low temperatures Good abrasion resistance Good processibility and thermal stability Rigidity and dimensional stability
DURETHAN** Polyamide 6 (formerly Nydur Polyamide 6) Pages 14-17	High strength, rigidity and hardness Excellent toughness and impact resistance High dynamic fatigue resistance Excellent abrasion and chemical resistance High heat resistance in reinforced grades Good electrical insulating properties
TEXIN and DESMOPAN Thermoplastic Polyurethane Pages 18-19	Excellent abrasion resistance Excellent resistance to fuels and oils High tensile and tear strength High elasticity and resilience Good vibration dampening Shore hardness range from 85A to 75D

* On January 1, 1992, all Mobay businesses began operating under the corporate name Miles Inc.
 ** Durethan polyamide was previously supplied by the corporate predecessor of Miles Inc. under the trademark Nydur.
 * Makroblend DP4-1370 resin (natural color) can be used for food-contact applications except for those in which the temperature exceeds 250°F and the food contains more than 50% alcohol. Since color possibilities for food-contact applications are limited, please contact your Miles representative for information on available colors and their limitations.

ENGINEERING THERMOPLASTICS BY MILES

Grades	Markets and Applications
General-Purpose High-Productivity Impact-Modified Glass-Reinforced Flame-Retardant Structural Foam Extrusion Medical Optical Lighting Automotive Lens	Automotive and Transportation: forward and rear lighting components, instrument panels, aircraft canopies Building and Construction: extrusion resin for monolayer and structured sheet, profiles Business Machines: computer and printer housings, sight windows Consumer: power tool housings, food storage containers, appliances, sporting goods Electrical/Electronic: electric meter covers, telephone components, lighting diffusers and lenses ^b Medical: diagnostic, cardiovascular and intravenous devices; drug delivery systems; packaging Optical: ophthalmic (prescription), safety and specialized lenses for the military, industrial and sports markets Optical Memory: audio compact discs, data storage discs Packaging: bottles, film
General-Purpose Flame-Retardant Medical	Automotive and Transportation: reflectors, lenses, and light pipes for interior and exterior lighting Consumer: steam iron water tanks, hair dryer components, microwave oven doors, gas range controls and ignition switches Electrical/Electronic: fuses, switch housings; lighting reflectors, diffusers and lenses Industrial/Mechanical: emergency equipment, face shields, indicator lenses ^b Medical: packaging, surgical lighting, autoclavable devices
General-Purpose High-Productivity Glass-Reinforced Flame-Retardant Flame-Retardant, Antimony/Bromine-Free Structural Foam	Automotive: interior and exterior parts, wheel covers, instrument panels Business Machines: computer, monitor and printer housings; general office equipment Consumer: household appliances, food service trays, smoke detectors, lawn and garden equipment Electrical/Electronic: modular plugs, wiring devices
Impact-Modified Glass-Reinforced Flame-Retardant ^a FDA-Compliant	Automotive: body panels, bumpers, interior switches Consumer: appliances, lawn and garden equipment, sporting goods, telecommunications equipment Electrical/Electronic: connectors, electrical housings, interrupters, switch housings Industrial/Mechanical: meter housings, pump housings, agricultural equipment
Unreinforced Impact-Modified Glass-Reinforced Mineral-Reinforced Mineral/Glass-Reinforced Reduced-Moisture and Impact-Modified versions of Glass-Reinforced and Mineral-Reinforced grades are available. Film grades available (not listed in table).	Automotive: interior and exterior parts, door handles, mirrors, wheel covers Consumer: furniture, lawn and garden equipment, power tool housings, sporting goods Electrical/Electronic: wiring devices, switch housings, fuse holders Industrial/Mechanical: pumps, fans, pneumatic tools, housings Packaging: film for packaging of food, chemicals, medical and industrial goods
Polyester Polyether Polyurethane/Polycarbonate Blends Medical Extrusion	Automotive: cars, gears, mechanical parts, exterior applications, side body molding Building and Construction: extrusion resins for film and sheet Consumer: golf balls, ski goggle frames, shoe components, ski boots Industrial/Mechanical: mine screens, animal identification tags, hydraulic seals, hoses, caster wheels, grain buckets ^b Medical: diagnostic devices, tubing and catheters, connectors

^b It is the responsibility of the medical device manufacturer to determine the suitability of all component parts and raw materials, including Apec, Makrolon, and Teflon resins, used in its final product in order to ensure safety and compliance with FDA requirements. This determination must include, as applicable, testing for suitability as an implant device and suitability as to contact with and/or storage of liquids including, without limitation, medication, blood, or other bodily fluids. Under no circumstances, however, may Apec, Makrolon or Teflon resin be used in any bodily implant applications for greater than 29 days. For aromatic grades of Teflon resins, longer-term uses are not permissible because possible hydrolysis of solid polyurethane may produce aromatic amines, such as MDA. The sterilization method and the number of sterilization cycles a part made from these resins can withstand will vary depending upon the type of resin, part design, and processing parameters. Therefore, the manufacturer must evaluate each application to determine the sterilization method and the number of sterilization cycles appropriate for exact end-use requirements. Parts molded or extruded from Teflon resins are sterilizable using ethylene oxide, radiation, or dry heat. Steam autoclaving and boiling water methods must not be used with aromatic grades of Teflon resin because possible hydrolysis may produce aromatic amines, such as MDA.

ENGINEERING THERMOSETS BY MILES

Thermosets

The Polymers Division produces polyurethane raw materials and systems for the automotive, appliance, construction and furniture industries, as well as many other markets, such as consumer, industrial/mechanical, medical, and specialty transportation. In addition to the specialty systems listed in this brochure, the Polyurethanes Department offers integral skin foams; elastomeric, microcellular soling systems for the production of shoe soles; semirigid foams, and high-resilience foams. Moreover, a full range of raw materials and additives includes diphenylmethane diisocyanate (MDI), toluene diisocyanate (TDI), and polyols. A complete line of equipment for polyurethane processing is produced by the division's Hennecke Machinery Group.

For information, please call
1-800-622-6004.

Products	Features
BAYFLEX Elastomeric Polyurethane RIM Systems Page 20	Two-component, MDI-based liquid systems Large-part moldability Wide range of flexural modulus Superior impact strength Light weight Excellent surface quality In-mold coating
BAYDUR STR Composite Polyurethane RIM Systems Page 21	Two-component, MDI-based liquid systems Exceptional impact strength and stiffness Used for large structural parts
BAYDUR Structural Foam Polyurethane RIM Systems Page 21	Two-component, MDI-based liquid systems Large-part moldability Stiffness High-gloss finish and excellent surface quality In-mold coating Used for thick and thin wall thicknesses
PRISM Solid Polyurethane RIM Systems Page 21	Two-component, MDI-based liquid systems Stiffness High strength-to-weight ratio Good chemical resistance Good heat deflection temperature Excellent surface quality
BAYTEC RE Elastomeric and Structural Polyurethane Spray Systems Page 22	Two-component, MDI-based liquid systems Low viscosity, solvent-free liquids (negligible VOCs) Used for structural parts, thin parts, and thin membranes Good adhesion to substrates Fast reaction and cure times for cast molding
BAYTEC RTM Polyurethane Systems for Resin Transfer Molding Page 22	Two-component, MDI-based liquid systems Low-viscosity, solvent-free liquids (negligible VOCs) High flexural modulus without postcure Outstanding impact resistance at high and low temperatures, with and without glass Fast reaction times and early, high green strength
BAYTEC Polyurethane Prepolymers for Cast Elastomers Page 23	MDI-based prepolymers Dynamic load-bearing ability Outstanding resilience Superior tear resistance Corrosion and abrasion resistance Flexible over a wide temperature range

ENGINEERING THERMOSETS BY MILES

Grades	Markets and Applications
Unfilled Glass-Filled	Agricultural/Construction Equipment: Hay conditioning rollers, tractor body panels and door frames Automotive: Fascias, body panels, aftermarket restyling packages Specialty Transportation: Heavy-duty truck bumpers, snowmobile hoods, work vehicles
General-Purpose, Foamed General-Purpose, Solid	Automotive: Bumper beams, inner door panels, interior trim Construction: Home entry door skins Consumer: Water sports equipment
General-Purpose Flame-Retardant	Agricultural/Construction Equipment: Tractor cab roofs and consoles Automotive: Aftermarket spoilers Construction: Window and door frames Consumer: Speaker housings, snow and water skis Electrical/Electronic: Instrumentation and equipment housings, Nema 1 and 12 enclosures, telecommunications equipment Medical: Analytical and diagnostic equipment housings
General-Purpose Flame-Retardant	Electrical/Electronic: Telecommunications equipment, instrumentation and equipment housings Medical: Analytical and diagnostic equipment housings, laboratory instrumentation
Elastomeric Structural	Automotive: Aftermarket restyling packages Consumer: On-deck marine accessories, spas and bathtubs Industrial/Mechanical: Industrial liners, dump truck liners, containers, agricultural parts Miscellaneous: Protection for wood, metal and concrete
General-Purpose	Automotive: Aftermarket restyling packages Consumer: Marine accessories, radar dishes Industrial/Mechanical: Pump housings, valve bodies, fan blades Specialty Transportation: Components for heavy trucks, recreational vehicles, tractors, and construction vehicles
Polyester Poly(tetramethylene ether) glycol Poly(propylene ether) glycol	Industrial/Mechanical: Tires and wheels, rolls, hydrocyclones, pipeline pigs, seals and gaskets, gears and sprockets, die-cut pads and chopper cots, belts, liners, classifier screens, conveyor belt scrapers, shock absorbers

MAKROLON POLYCARBONATE

Makrolon Polycarbonate

THERMOPLASTICS			General-Purpose				Extrusion
			High-Productivity				
			3200 3100	2800 2600	FCR-2405 FCR-2407 FCR-2458	2205	HMS-3118
GENERAL							
Specific Gravity	D 792		1.20	1.20	1.20	1.20	1.20
Density	D 792	lb/in ³	0.043	0.043	0.043	0.043	0.043
Specific Volume	D 792	in ³ /lb	23.1	23.1	23.1	23.1	23.1
Mold Shrinkage	D 955	in/in	0.006-0.008	0.006-0.008	0.005-0.007	0.005-0.007	0.006-0.008
Water Absorption (Immersion at 73°F):	D 570	%					
24 Hours		%	0.15	0.15	0.15	0.15	0.15
Equilibrium		%	0.35	0.35	0.35	0.35	0.35
Melt Flow Rate** at 300°C/1.2-kg Load	D 1238	g/10 min	4.5 (3200)	10 (2800)	20.5	33	<3
		g/10 min	6.5 (3100)	12 (2600)			
OPTICAL							
Transmittance at 0.125-in Thickness	D 1003	%	88	88	88	88	87
Haze at 0.125-in Thickness	D 1003	%	1.0	1.0	1.0	1.0	1.0
Refractive Index	D 542		1.586	1.586	1.584	1.584	1.586
MECHANICAL							
Tensile Stress at Yield	D 638	lb/in ²	9,100	9,100	9,100	9,100	9,100
Tensile Stress at Break	D 638	lb/in ²	10,500	10,500	10,000	8,700	10,000
Tensile Elongation at Yield	D 638	%	6	6	6	6	6
Tensile Elongation at Break	D 638	%	125	120	120	110	110
Tensile Modulus	D 638	lb/in ² ×10 ³	350	350	350	330	350
Flexural Stress at 5% Strain	D 790	lb/in ²	12,500	12,500	12,000	12,000	12,400
Flexural Modulus	D 790	lb/in ² ×10 ³	330	330	330	340	340
Impact Strength, Notched Izod:		ftlb/in					
0.125-in Thickness, 73°F	D 256	ftlb/in	18	17	14	12	17
0.250-in Thickness, 73°F	D 256	ftlb/in	2.4	2.2	2		2.2
Rockwell Hardness	D 785	M Scale	75	75	75	75	
		R Scale	118	118	118	118	124
Falling Dart Impact (10-lb Wt., 1-in Dia. Dart)	(Miles)	ftlb					
THERMAL							
Deflection Temperature, Unannealed:	D 648	°F					
264-psi Load		°F	270	268	259	252	266
66-psi Load		°F	288	280	273	273	280
Coefficient of Linear Thermal Expansion	D 696	in/in/°F	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05
Thermal Conductivity	C 177	Btu-in/(h-ft ² -°F)	1.39	1.39	1.39	1.39	1.39
Specific Heat	D 2766	Btu/(lb-°F)	0.28	0.28	0.28	0.28	0.28
Relative Temperature Index ^a	(UL746B)						
Electrical		°C	125	125	125		75
Mechanical with Impact		°C	115	115	115		75
Mechanical without Impact		°C	125	125	125		75
Vicat Softening Temperature: Rate A	D 1525	°F	315	315	304	289	307
FLAMMABILITY†							
Oxygen Index	D 2863	%	26	26	26	26	26
UL94 Flame Class:	(UL94)						
0.062-in (1.57-mm) Thickness		Rating	HB	V-2	V-2		HB ^b
0.125-in (3.18-mm) Thickness		Rating	HB	V-2	V-2		
0.144-in (3.66-mm) Thickness		Rating					
0.175-in (4.45-mm) Thickness		Rating	V-2	V-0	V-2		
0.250-in (6.35-mm) Thickness		Rating					
ELECTRICAL							
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	1.0 E + 16	1.0 E + 16	1.0 E + 16	1.0 E + 16	1.0 E + 16
Surface Resistivity	D 257	ohm	1.0 E + 15	1.0 E + 15	1.0 E + 15	1.0 E + 15	1.0 E + 15
Dielectric Strength (Short Time under Oil at 73°F, 0.062-in Thickness)	D 149	V/mil	760	760	760	760	760
Dielectric Constant (Tinfoil Electrodes): 60 Hz	D 150		3.0	3.0	3.0	3.0	3.0
1 MHz			2.9	2.9	2.9	2.9	2.9
Dissipation Factor (Tinfoil Electrodes): 60 Hz	D 150		0.0009	0.0009	0.0008	0.0008	0.0009
1 MHz			0.01	0.01	0.01	0.01	0.01
Arc Resistance: Stainless Steel Electrodes	D 495	s	11	11	11		11
Tungsten Electrodes		s	120	120	120		120

* These items are provided as general information only. They are approximate values and are not part of the product specification.

** For information on using melt flow as a quality control procedure, see Miles processing literature.

† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

MAKROLON POLYCARBONATE

Makrolon Polycarbonate (continued)

Flame-Retardant			Impact-Modified		Glass-Reinforced		Structural Foam		
High-Productivity						Flame-Retardant	(Properties at indicated foam density)		
FCR-6255	6355 6455	6485	T-7435	T-7855	8325 20% Glass	9415 10% Glass	SF-600 0.250 in	SF-800 0.250 in	SF-610 0.250 in
1.20	1.20	1.20	1.20	1.19	1.35	1.27	(Solid) 1.23 (Foam) 0.90	(Solid) 1.23 (Foam) 0.90	(Solid) 1.27 (Foam) 0.95
0.043	0.043	0.043	0.043	0.043	0.049	0.046	(Solid) 0.044 (Foam) 0.033	(Solid) 0.044 (Foam) 0.033	(Solid) 0.046 (Foam) 0.034
23.1 0.005-0.007	23.1 0.006-0.008	23.1 0.006-0.008	23.1 0.005-0.007	23.3 0.006-0.008	20.4 0.003-0.004	21.8 0.003-0.005	0.005-0.007	0.005-0.007	0.004-0.006
0.15	0.15	0.15	0.15	0.15	0.12	0.13	0.15	0.15	0.15
0.35	0.35	0.35	0.35	0.35	0.29	0.32	0.30	0.30	0.30
20.5	16 (6355) 12 (6455)	12	17.5	12	5	7	7	5.5	6.5
Opaque Only	87 (6455) 1.2 (6455) 1.586	Opaque Only	Opaque Only	Opaque Only	Opaque Only	Opaque Only	Opaque Only	Opaque Only	Opaque Only
9,100 10,000 6 110 350 12,100 330	9,100 10,000 6 110 350 13,200 330	9,100 10,500 6 110 350 13,200 330	7,900 8,100 6 110 300 12,000 305	9,100 9,000 6 110 340 12,500 320	15,000 5 19,500 800	11,600 10,000 5 10 580 15,000 500	5,600 5 300 10,800 330	6,100 5 300 11,000 340	6,300 4 310 12,000 405
13 2 75 118	16 2 70	12 ^d 2 70	13.9 10 53 122	15 12	3 2.4 81 6.0	2 75	30	35	22
259 273 3.9 E-05 1.39 0.28	264 277 3.9 E-05 1.39 0.28	262 277 3.9 E-05 1.39 0.28	250 266 3.7 E-05	259 273 3.9 E-05	290 293 1.7 E-05 1.53 0.27	284 295 2.1 E-05 1.46 0.27	261 280 2.8 E-05 1.05 0.28	261 280 2.8 E-05 1.05 0.28	273 292 1.9 E-05 0.92 0.29
125 115 125 304	125 115 125 315	125 110 125 315	293	290	75 75 75	125 115 125	75 75 75	75 75 75	75 75 75
35 V-2 V-0 V-0	35 V-2 V-0 V-0	35 V-0 V-0/SVA V-0		26	32 V-0 ^c	35 V-0 V-0/SVA ^c V-0/SVA	V-0/SVA	V-0/SVA	V-0 V-0/SVA V-0/SVA
1.0 E + 16 1.0 E + 15	1.0 E + 16 1.0 E + 15	1.0 E + 16 1.0 E + 15			1.0 E + 16 1.0 E + 14	1.0 E + 16 1.0 E + 14	1.0 E + 16 1.0 E + 15	1.0 E + 16 1.0 E + 15	1.0 E + 16 1.0 E + 15
760 3.0 2.9 0.0009 0.01	760 3.0 2.9 0.0009 0.01	766 3.6 3.0 0.0009 0.01		>400 3.0 3.1 0.0018 0.011	760 3.2 3.2 0.0009 0.01	760 3.2 3.0 0.0008 0.008	>209 2.6 2.6 0.0031 0.0022	>400 3.0 2.9 0.0031 0.0022	>400 3.1 3.0 0.0031 0.0022
115	115	115		100	30-80	115			

^a The thickness at which relative temperature index values are reported in this section corresponds to the thinnest specimen thickness for which a UL94 flame class rating appears in the flammability section.

^b Natural color.

^c Natural and black colors.

^d Value depends on pigment package.

MAKROLON POLYCARBONATE

Makrolon Polycarbonate (continued)

THERMOPLASTICS			Specialty				
Typical Physical Properties			Lighting		Optical		
ASTM Test Method (Units)			LTC-2523	LTC-3123	LQ-2847 1006 Tint	LQ-3147 1006 Tint	LQ-3187
GENERAL							
Specific Gravity	D 792		1.20	1.20	1.20	1.20	1.20
Density	D 792	lb/in ³	0.043	0.043	0.043	0.043	0.043
Specific Volume	D 792	in ³ /lb	23.1	23.1	23.1	23.1	23.1
Mold Shrinkage	D 955	in/in	0.005-0.007	0.006-0.008	0.005-0.008	0.005-0.008	0.006-0.008
Water Absorption (Immersion at 73°F):	D 570						
24 Hours		%	0.15	0.15	0.15	0.15	0.15
Equilibrium		%	0.35	0.35	0.35	0.35	0.35
Melt Flow Rate:** 300°C/1.2-kg Load	D 1238	g/10 min	11	6.5	12	6.5	6.5
320°C/1.2-kg Load		g/10 min					
OPTICAL							
Transmittance at 0.125-in Thickness	D 1003	%	87°	87°	89	89	87
Haze at 0.125-in Thickness	D 1003	%	1.0°	1.0°	1.0	1.0	1.0
Refractive Index	D 542+		1.586°	1.586°	1.586	1.586	
UV Cut-Off Wavelength at 0.125-in Thickness	(Miles)	nm			380	380	400
MECHANICAL							
Tensile Stress at Yield	D 638	lb/in ²	9,100	9,100	9,100	9,100	9,100
Tensile Stress at Break	D 638	lb/in ²	10,500	10,500	10,500	10,500	10,500
Tensile Elongation at Yield	D 638	%	6	6	6	6	6
Tensile Elongation at Break	D 638	%	120	125	120	125	125
Tensile Modulus	D 638	lb/in ² x 10 ⁹	350	350	350	350	350
Flexural Stress at 5% Strain	D 790	lb/in ²	12,500	12,500	12,500	12,500	12,500
Flexural Modulus	D 790	lb/in ² x 10 ⁹	330	330	330	330	330
Impact Strength:		ft-lb/in					
Notched Izod, 0.125-in Thickness, 73°F	D 256	ft-lb/in	16	18	16	16	16
Notched Izod, 0.250-in Thickness, 73°F	D 256	ft-lb/in	2.2	2.4	2.2	2.2	2.1
Unnotched, 0.125-in Thickness, 73°F	D 4812	ft-lb/in					
Unnotched, 0.125-in Thickness, -40°F	D 4812	ft-lb/in					
Rockwell Hardness	D 785	M Scale	118	118	120	120	120
		R Scale					
Instrumented Impact, Total Energy:	D 3763	ft-lb					
0.125-in Thickness, 15 mph, 3-in Clamp		ft-lb					
73°F							
-20°F							
THERMAL							
Deflection Temperature, Unannealed:	D 648	°F	266	270	264	266	266
264-psi Load		°F	275	287	277	284	284
66-psi Load		in/in/°F	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05
Coefficient of Linear Thermal Expansion	D 696	Btu-in/(in ² °F)	1.39	1.39	1.39	1.39	1.39
Thermal Conductivity	C 177	Btu/(lb·°F)	0.28	0.28	0.28	0.28	0.28
Specific Heat	D 2766						
Relative Temperature Index at 0.062-in Thickness:	(UL748B)	°C	125	125	125	125	
Electrical		°C	115	115	115	115	
Mechanical with Impact		°C	125	125	125	125	
Mechanical without Impact		°F	315	315	315	315	315
Vicat Softening Temperature: Rate A	D 1525	°F					
Rate B		°F					
FLAMMABILITY†							
Oxygen Index	D 2863	%	26	26	26		26
UL94 Flame Class:	(UL94)	Rating	V-2	HB	V-2	HB	
0.062-in (1.57-mm) Thickness		Rating	V-2	HB	V-2	HB	
0.125-in (3.18-mm) Thickness		Rating	V-0	V-2	V-0	V-2	
0.250-in (6.35-mm) Thickness		Rating					
ELECTRICAL							
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	1.0 E + 16	1.0 E + 16	1.0 E + 16	1.0 E + 16	1.0 E + 16
Surface Resistivity	D 257	ohm	1.0 E + 15	1.0 E + 15	1.0 E + 15	1.0 E + 15	1.0 E + 15
Dielectric Strength (Short Time under Oil, 73°F)*	D 149	V/mil	>400	>400	>400	>400	>400
Dielectric Constant (Tinfoil Electrodes): 60 Hz	D 150		3.0	3.0	3.0	3.0	3.0
1 MHz			2.9	2.9	2.9	2.9	2.9
Dissipation Factor (Tinfoil Electrodes): 60 Hz	D 150		0.0009	0.0009	0.0009	0.0009	0.0009
1 MHz			0.01	0.01	0.01	0.01	0.01
Arc Resistance: Stainless Steel Electrodes	D 495	s			11	11	11
Tungsten Electrodes		s			30-90	30-90	30-90

* These items are provided as general information only. They are approximate values and are not part of the product specification.

** For information on using melt flow as a quality control procedure, see Miles processing literature.

† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

APEC HIGH-HEAT POLYCARBONATE

Makrolon Polycarbonate (continued)

Specialty			Medical
Automotive Lens			
AL-2247 1068 Tint	AL-2447 1068 Tint	AL-2647 1068 Tint	Rx-2530 1118 Tint
1.20 0.043 23.1 0.005-0.007	1.20 0.043 23.1 0.005-0.007	1.20 0.043 23.1 0.006-0.008	1.20 0.043 23.1 0.006-0.008
0.15 0.35 33	0.15 0.35 19	0.15 0.35 12	0.15 0.30 15
87 1.0 1.582	87 1.0 1.584	87 1.0 1.586	78 1.2 1.586
8,000 8,700 6 100 330 12,000 330 10 No Break No Break	9,100 10,000 6 120 350 12,000 330 14 2 75 118	9,100 10,500 6 120 350 12,500 330 15 2 75 118	9,100 10,500 6 120 350 12,500 330 15.6 1.4 87
254 270 291	259 273 3.9 E-05 1.39 0.28 125 115 125 304	264 275 3.9 E-05 1.39 0.28 125 115 125 315	259 273 3.9 E-05
	26 V-2 V-2 V-2	26 V-2 V-2 V-0	
	1.0 E + 16 1.0 E + 15 760 3.0 2.9 0.0008 0.01 11 30-90	1.0 E + 16 1.0 E + 15 760 3.0 2.9 0.0009 0.01	1.0 E + 1.0 E + >400 3.0 3.0 0.001 0.01 11 30-90

Apec High-Heat Polycarbonate

General-Purpose					Flame-Retardant	
HT DP9-9331	HT DP9-9340 ^b HT DP9-9341	HT DP9-9350 ^b HT DP9-9351	HT DP9-9351	HT DP9-9371	HT DP9-9354T	HT DP9-9354
1.18 0.043 23.5 0.007-0.008	1.17 0.042 23.6 0.007-0.008	1.15 0.042 24.1 0.008-0.009	1.15 0.042 24.1 0.008-0.009	1.14 0.041 24.3 0.008-0.009	1.15 0.042 24.1 0.008-0.009	1.15 0.042 24.1 0.008-0.009
0.2	0.2	0.2	0.2	0.2	0.2	0.2
7-10	5-8	2-5	1-3	0.5-2	2-5	2-5
88 1.0 1.581	88 1.0 1.578	88 1.0 1.572	88 1.0 1.570	88 1.0 1.565	87 1.2	Opaque Only
9,300 9,500 6 90 325 12,500 330 12 No Break No Break 75 125 50 48	9,600 9,300 6 80 325 12,500 330 6 No Break No Break 83 127	9,600 9,000 6 80 325 12,500 330 2 No Break No Break 84 127 49 47	9,800 8,600 6 70 325 12,500 330 1.8 No Break No Break 89 127	10,000 8,300 6 70 325 12,500 330 1.5 No Break No Break 91 127 46 39	9,600 9,000 6 50 325 12,500 330 1.8 No Break No Break	9,600 9,000 6 30 325 12,500 330 1.8 No Break No Break 43 34
284 306 4.2 E-05 140 130 140 320	302 324 4.2 E-05 75 75 75 341	324 345 4.2 E-05 150 130 150 365	336 365 4.2 E-05 75 75 75 383	354 383 4.2 E-05 75 75 75 401	324 345 4.2 E-05 75 75 75 365	324 345 4.2 E-05 75 75 75 365
24 HB HB	24 HB HB	24 HB HB	24 HB HB	24 HB HB	35 V-2 V-0	35 V-0 V-0/5VA
>1.0 E+16 >1.0 E+16 >400 3.0 2.9 0.001 0.01	>1.0 E+16 >1.0 E+16 >400 3.0 2.9 0.001 0.01	>1.0 E+16 >1.0 E+16 >400 3.0 2.9 0.001 0.01	>1.0 E+16 >1.0 E+16 >400 2.9 2.9 0.001 0.01	>1.0 E+16 >1.0 E+16 >400 2.8 2.8 0.001 0.01	1.0 E+15 1.0 E+14 >400 2.8 2.9 0.005 0.01	1.0 E+15 1.0 E+14 >400 2.8 2.9 0.003 0.01

^a Dielectric strength properties are reported at 0.062-inch thickness for grades of Makrolon polycarbonate and at 0.125-inch thickness for grades of Apec high-heat polycarbonate.

^b HT DP9-9340 and HT DP9-9350 are medical grades of Apec resin.

^c This value does not apply to color 3331 white.

BAYBLEND POLYCARBONATE/ABS BLEND

Bayblend PC/ABS Blend

THERMOPLASTICS			General-Purpose				
						High-Productivity	
			T 45 MN	T 65 MR	6 65 MN	T 44	T 64
GENERAL							
Specific Gravity	D 792		1.10	1.13	1.15	1.10	1.13
Density	D 792	lb/in ³	0.040	0.041	0.041	0.040	0.041
Specific Volume	D 792	in ³ /lb	25.2	24.1	24.3	25.2	24.1
Mold Shrinkage	D 955	in/in	0.005-0.007	0.005-0.007	0.005-0.007	0.005-0.007	0.005-0.007
Water Absorption (Immersion at 73°F):	D 570	%	0.2	0.2	0.2	0.2	0.2
24 Hours		%	0.7	0.6	0.6	0.7	0.6
Equilibrium		%	5-11	5-11	5-11	10-16	10-16
Melt Flow Rate** at 250°C/5-kg Load	D 1238	g/10 min					
Spiral Flow Length at 0.100-in Thickness:	(Miles)	in	22.5	19.0	16.5	23.5	22.3
490°F Melt Temperature		in	26.0	23.0	20.5	27.0	26.0
525°F Melt Temperature							
MECHANICAL							
Tensile Stress at Yield	D 638	lb/in ²	6,500	7,200	8,000	6,500	7,200
Tensile Stress at Break	D 638	lb/in ²	5,800	6,500	7,200	5,800	6,500
Tensile Elongation at Yield	D 638	%	4	4	5	3	4
Tensile Elongation at Break	D 638	%	70	80	85	60	70
Tensile Modulus	D 638	lb/in ² x 10 ³			11,600	8,700	9,400
Flexural Stress at 5% Strain	D 790	lb/in ²	10,100	10,900	320	290	305
Flexural Modulus	D 790	lb/in ² x 10 ³	290	305			
Impact Strength, Notched Izod:	D 256	ft-lb/in	9.0	10.0	11.0	8.0	9.0
0.125-in Thickness, 73°F		ft-lb/in	5.0	6.0	7.0	4.5	5.0
0.125-in Thickness, -40°F		R Scale	114	118	119	95	118
Rockwell Hardness	D 785						
Instrumented Impact, Total Energy:	D 3763						
0.125-in Thickness, 15 mph, 3-in Clamp		ft-lb	30	33	33		33
73°F		ft-lb	28	30	33		29
-22°F		ft-lb					
0.180-in Thickness, 2.5 mph, 3-in Clamp, 73°F		ft-lb					
0.250-in Thickness, 2.5 mph, 3-in Clamp, 73°F		ft-lb					
THERMAL							
Deflection Temperature, Unannealed:	D 648	°F	210	220	230	210	210
264-psi Load		°F	220	255	265	220	248
66-psi Load		in/in/°F	4.6 E-05	4.3 E-05	4.0 E-05	4.6 E-05	4.3 E-05
Coefficient of Linear Thermal Expansion	D 696						
Relative Temperature Index at 0.062-in Thickness:	(UL746B)	°C	60	60	60	60	60
Electrical		°C	60	60	60	60	60
Mechanical with Impact		°C	60	60	60	60	60
Mechanical without Impact		°F	230	250	270	230	250
Vicat Softening Temperature: Rate B/120	(ISO 306)						
FLAMMABILITY†							
Oxygen Index	D 2863	%	21	23	24	21	23
UL94 Flame Class:	(UL94)						
0.062-in (1.57-mm) Thickness		Rating	HB	HB	HB	HB	HB
0.089-in (2.29-mm) Thickness		Rating	HB	HB	HB	HB	HB
0.100-in (2.54-mm) Thickness		Rating	HB	HB	HB	HB	HB
0.125-in (3.18-mm) Thickness		Rating	HB	HB	HB	HB	HB
ELECTRICAL							
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	>1.0 E + 16	>1.0 E + 16	>1.0 E + 16	>1.0 E + 16	>1.0 E + 16
Surface Resistivity	D 257	ohm	>1.0 E + 14	>1.0 E + 14	>1.0 E + 14	>1.0 E + 14	>1.0 E + 14
Dielectric Strength (Short Time under Oil at 73°F, 0.062-in Thickness)	D 149	V/mil	600	600	600	600	600
Dielectric Constant (Tinfoil Electrodes): 60 Hz	D 150						
1 MHz			0.004	0.004	0.004	0.004	0.004
Dissipation Factor (Tinfoil Electrodes): 60 Hz	D 150		0.007	0.007	0.008	0.007	0.007
1 MHz							

* These items are provided as general information only. They are approximate values and are not part of the product specification.

** For information on using melt flow as a quality control procedure, see Miles processing literature.

† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

BAYBLEND POLYCARBONATE/ABS BLEND

Bayblend PC/ABS Blend (continued)

General-Purpose High-Productivity	Flame-Retardant					Glass-Reinforced		Structural Foam (Properties at indicated foam density)	Blow Molding/ Extrusion
				Antimony/Bromine-Free		T 88-2H 10% Glass	T 88-4N 20% Glass	SF 1443 0.250 in	DP2-1500
T 84	FR 1439	FR 1440	FR 1441	FR 90	FR 110				
1.15	1.17	1.18	1.18	1.17	1.19	1.20	1.25	(Solid) 1.18 (Foam) 0.90 (Solid) 0.043 (Foam) 0.033	1.21
0.041	0.042	0.043	0.043	0.042	0.043	0.043	0.045		0.043
24.3 0.005-0.007	23.7 0.0043-0.0055	23.5 0.0045-0.0056	23.5 0.0048-0.0058	24.8 0.003-0.005	23.2 0.004-0.006	23.1 0.003-0.004	22.2 0.002-0.003	0.005-0.007	
0.2 0.6 10-16	0.15 24	0.15 19	0.15 16	0.15 35	0.15 35	0.2 0.6	0.2 0.6	0.2 0.6	3-10 10
19.0 22.8	27.0 32 ^a	22.5 27.0	18.0 22.0	28.0 32 ^a	22.5				
8,000 6,500 4 75 10,200 320 10.0 6.0 119 33 33	7,700 5,800 3.5 50 380 12,600 360 6.0 115 34	8,000 6,500 4 60 390 13,000 380 7.5 119 35	8,700 7,300 4 60 390 13,900 380 9.5 121 36	8,700 6,500 4 70 400 14,500 400 5.5 121 42	8,700 8,100 4 90 380 13,800 390 14 122 38	9,400 8,700 3 5 16,000 580 1.5	10,900 10,900 2 2 18,900 870 1.4	6,100 3.4 11,600 380 15 22	7,700 7,600 3.8 90 12,600 329 13 38 33
226 262 4.0 E-05 60 60 60 270	180 195 3.9 E-05 90 70 90 195	195 210 3.9 E-05 95 80 95 210	210 230 3.9 E-05 95 85 95 230	185 203 3.9 E-05 85 75 80 200	203 212 95 85 85 226	240 257 2.3 E-05 60 60 60 270	240 266 1.8 E-05 60 60 60 275	171 201 60 ^d 60 ^d 60 ^d	221 60 60 60 264
24 HB HB HB HB	28 V-0 V-0/5VB ^b V-0/5VB ^c V-0/5VB	30 V-0 V-0/5VB ^b V-0/5VB ^c V-0/5VB	30 V-0 V-0/5VB V-0/5VB V-0/5VB	30 V-0 V-0/5VB V-0/5VB V-0/5VB	30 V-0 V-0/5VB V-0/5VB V-0/5VA	24 HB HB HB HB	24 HB HB HB HB	V-0 V-0	V-0 V-0/5VB ^b
>1.0 E + 16 >1.0 E + 14 600 0.004 0.008	>1.0 E + 16 >1.0 E + 14 760 3.0 2.9 0.005 0.007	>1.0 E + 16 >1.0 E + 14 760 3.0 2.9 0.004 0.007	>1.0 E + 16 >1.0 E + 14 760 3.0 2.9 0.004 0.007	>1.0 E + 16 >1.0 E + 14 760 3.0 2.9 0.005 0.007		>1.0 E + 16 >1.0 E + 14 0.002 0.009	>1.0 E + 16 >1.0 E + 14 0.002 0.009	>1.0 E + 16 >1.0 E + 14	

- ^a Equipment capability exceeded.
^b Red, black, white and yellow colors.
^c Natural color.
^d Thickness of relative temperature index is reported at 0.118 inch.

MAKROBLEND POLYCARBONATE BLEND

Makroblend PC Blend

THERMOPLASTICS			Impact-Modified			
General Physical Properties			Glass-Reinforced			
			UT 1018	UT 400 UT 403	UT 620 G 10% Glass	UT 640 G 20% Glass
GENERAL						
Specific Gravity	D 792		1.22	1.22	1.31	1.37
Density	D 792	lb/in ³	0.044	0.044	0.047	0.050
Specific Volume	D 792	in ³ /lb	22.7	22.7	21.1	20.2
Mold Shrinkage	D 955	in/in	0.005-0.009	0.005-0.008	0.001-0.006	0.001-0.006
Water Absorption (Immersion at 73°F):	D 570					
24 Hours		%	0.16	0.11	0.10	0.08
Equilibrium		%	0.30	0.25	0.24	0.23
Melt Flow Rate** at 265°C/5-kg Load	D 1238	g/10 min	8-12	26-34		
Spiral Flow Length at 0.100-in Thickness:	(Miles)	in	16	28		
525°F Melt Temperature						
MECHANICAL						
Tensile Stress at Yield	D 638	lb/in ²	7,000	7,900	11,000	13,000
Tensile Stress at Break	D 638	lb/in ²	7,600	8,000	9,000	12,000
Tensile Elongation at Yield	D 638	%	5	5	5	5
Tensile Elongation at Break	D 638	%	165	151	5	5
Flexural Stress at 5% Strain	D 790	lb/in ²	10,700	12,400	19,000	23,600
Flexural Modulus	D 790	lb/in ² x 10 ⁹	300	338	560	850
Impact Strength, Notched Izod:	D 256					
0.125-in Thickness, 73°F		ft-lb/in	18	15	2.6	2.4
0.125-in Thickness, -20°F		ft-lb/in	13	3	2	2
0.125-in Thickness, -40°F		ft-lb/in	8	2	2	2
0.250-in Thickness, 73°F		ft-lb/in	15	4		
Rockwell Hardness	D 785	R Scale	114	121	113	115
Instrumented Impact, Total Energy:	D 3763					
0.125-in Thickness, 15 mph, 3-in Clamp						
73°F		ft-lb	39	41		
-20°F		ft-lb	39	42		
-40°F		ft-lb	38	41		
THERMAL						
Deflection Temperature, Unannealed:	D 648					
264-psi Load		°F	190	248	237	252
66-psi Load		°F	239	273	293	354
Coefficient of Linear Thermal Expansion	D 696	in/in/°F	4.0 E-05	3.7 E-05	2.6 E-05	2.2 E-05
Relative Temperature Index at 0.062-in Thickness:	(UL746B)					
Electrical		°C	75	75	75	75
Mechanical with Impact		°C	75	75	75	75
Mechanical without Impact		°C	75	75	75	75
Vicat Softening Temperature: Rate B	D 1525	°F				
FLAMMABILITY†						
UL94 Flame Class:	(UL94)					
0.062-in (1.57-mm) Thickness		Rating	HB	HB	HB ^a	HB ^a
0.125-in (3.18-mm) Thickness		Rating	HB	HB		
0.250-in (6.35-mm) Thickness		Rating				
ELECTRICAL						
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	>2.6 E + 15	>7.4 E + 15	>1.6 E + 15	>1.4 E + 15
Dielectric Strength (Short Time under Oil at 73°F, 0.062-in Thickness)	D 149	V/mil	713	704	>700	>700
Dielectric Constant (Tinfoil Electrodes): 1 MHz	D 150		3.06	3.1	3.2	3.3
Dissipation Factor (Tinfoil Electrodes): 1 MHz	D 150		0.014	0.009	0.0008	0.0009

* These items are provided as general information only. They are approximate values and are not part of the product specification.

** For information on using melt flow as a quality control procedure, see Miles processing literature.

† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

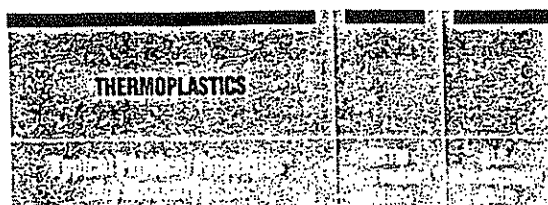
^a Black color.

MAKROBLEND POLYCARBONATE BLEND**Makroblend PC Blend (continued)**

Impact-Modified		
<i>Flame-Retardant</i>	<i>FDA-Compliant</i>	
DP4-1358	DP4-1377	DP4-1370
1.30 0.047 21.3 0.005-0.007	1.28 0.046 22 0.005-0.008	1.22 0.044 22.7 0.005-0.007
0.07 0.22 16-22	0.09 0.28 10-20	0.17 14-20
24	19	20
6,900 7,400 5 130 13,800 380	8,100 7,500 5 120 12,000 318	8,200 7,900 5 115 13,000 340
13 3	15 5 4	15
12 122	10 120	2 117
39 40 39	40 37 35	36 40 37
212 239 3.2 E-05	222 255 3.7 E-05	240 271 3.5 E-05
95 75 95	75 75 75	315
V-0 V-0/SVA V-0	V-0 V-0/SVA	
5.9 E + 15 740 3.02 0.0007		

DURETHAN POLYAMIDE 6

Durethan Polyamide 6



THERMOPLASTICS		
GENERAL		
Specific Gravity	D 792	
Density	D 792	lb/in ³
Specific Volume	D 792	in ³ /lb
Mold Shrinkage:		
Flow Direction	(Miles)	in/in
Cross-Flow Direction		in/in
Water Absorption (0.125-in Thickness):		%
24-Hour Immersion	D 570	
Equilibrium (73°F):	(DIN 53495)	%
In Air (50% RH)		%
In Water		%
MECHANICAL		
Tensile Stress at Break	D 638	lb/in ²
Tensile Elongation at Break	D 638	%
Tensile Modulus	D 638	lb/in ² × 10 ³
Flexural Stress at 5% Strain	D 790	lb/in ²
Flexural Strength	D 790	lb/in ²
Flexural Modulus	D 790	lb/in ² × 10 ³
Impact Strength, Notched Izod:	D 256	ft-lb/in
0.125-in Thickness, 73°F		ft-lb/in
0.125-in Thickness, -40°F		
THERMAL		
Deflection Temperature, Unannealed:	D 648	°F
264-psi Load		°F
66-psi Load		
FLAMMABILITY†		
UL94 Flame Class:	(UL94)	Rating
0.016-in (0.40-mm) Thickness		Rating
0.032-in (0.81-mm) Thickness		Rating
0.062-in (1.57-mm) Thickness		Rating
ELECTRICAL		
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm
Surface Resistivity	D 257	ohm
Dielectric Strength:	(DIN 53481)	V/mil
0.118-in Thickness		
Dielectric Constant (Tinfoil Electrodes):	D 150	
50 Hz		
1 MHz		
Dissipation Factor (Tinfoil Electrodes):	D 150	
50 Hz		
1 MHz		
Arc Resistance (Tungsten Electrodes)	D 495	s
Comparative Tracking Index	D 3638	V

Unreinforced				Impact-Modified									
B 30 S B 51 SX		B 40 SX		BC 30		BC 40		BC 303					
Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned
1.14		1.14		1.10		1.10		1.07					
0.041		0.041		0.040		0.040		0.039					
24.3		24.3		25.2		25.2		25.8					
0.012		0.012		0.013		0.015		0.016					
0.011		0.013		0.017		0.019		0.016					
1.5		1.5		1.5		1.5		1.6					
3.0		3.0		2.7		2.7		1.9					
10.0		10.0		9.0		9.0		7.0					
7,250	8,700	8,000	8,000	10,200	8,000	10,200	5,800	6,500	6,500				
35	>200	70	>200	50	>200	75	>200	>200	>200				
464	159	450	145	406	174	406	174	254	109				
16,700	5,080	16,700	5,080	13,000	4,400	13,800	4,400	8,700	2,900				
392	102	392	102	319	116	334	116	232	102				
1.1	14.0	1.3	18.7	1.7	17.8	3.0	2.1	17.8	18.7				
				1.5	1.5	2.1	2.1	2.8	3.7				
140		140		149		158		140					
356		356		329		365		320					
V-2 ^a													
V-2		HB		HB ^a		HB		HB					
1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+14	1.0E+12	1.0E+14	1.0E+12	1.0E+15	1.0E+12				
1.0E+13	1.0E+12	1.0E+13	1.0E+12	1.0E+12	1.0E+10	1.0E+12	1.0E+10	1.0E+15	1.0E+14				
762	889	762	889	889	762	889	762	813	813				
3.8	20.0	3.8	16	3.7	14	3.7	14	3.5	10.0				
3.4	4.6	3.4	4.7	3.3	5.8	3.3	5.8	3.1	4.5				
0.05	2.30	0.05	2.80	0.04	2.45	0.04	2.45	0.04	1.50				
0.07	0.40	0.06	0.40	0.06	1.30	0.06	0.37	0.05	0.70				
600		600		600		600		600					

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Miles value pending UL recognition.

^a Natural color.

Note 1

Dry as Molded: refers to a moisture content less than 0.2% by weight.

Conditioned: refers to an equilibrium moisture content in a standard laboratory atmosphere of 73°F and 50% relative humidity.

Note 2

Glass-Reinforced: refers to reinforcement with glass fibers except in the case of BG 30 X, which is reinforced with glass fibers and glass beads.

DURETHAN POLYAMIDE 6**Durethan Polyamide 6 (continued)**

Impact-Modified BC 402		Glass-Reinforced										Glass-Reinforced, Impact-Modified									
		BKV 15 H 15% Glass		BKV 30 H 30% Glass		BKV 40 H 40% Glass		BKV 50 H 50% Glass		BKV 115 15% Glass		BKV 130 30% Glass		BKV 140 40% Glass		BKV 35.2 35% Glass					
Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned
1.08		1.23		1.36		1.46		1.57		1.23		1.36		1.46		1.41					
0.039		0.044		0.049		0.053		0.057		0.044		0.049		0.053		0.051					
25.6		22.5		20.4		19.0		17.6		22.5		20.4		19.0		19.6					
0.016		0.003		0.003		0.003		0.003		0.003		0.003		0.003		0.003					
0.016		0.009		0.009		0.008		0.007		0.009		0.009		0.008		0.008					
1.7		1.3		1.0		0.85		0.80		1.30		1.00		0.85		0.90					
2.0		2.5		2.1		1.8		1.5		2.3		1.8		1.6		1.9					
8.0		8.5		7.0		6.0		5.0		8.5		7.0		6.0		6.5					
6,500	6,500	18,900	10,200	26,100	14,500	29,000	17,400	30,500	21,800	18,900	9,400	23,200	14,500	26,100	17,400	26,800	16,700				
>200	>200	3	5.5	3	6	3	4	2	3.5	7	9	4	7	3.5	6.5	2.5	5				
319	131	899	450	1,334	812	1,711	1,073	2,176	1,378	827	421	1,305	725	1,595	1,015	1,450	1,015				
11,600	3,600																				
290	109	29,000	17,400	40,600	24,700	47,900	29,000	50,800	31,900	27,600	14,500	37,700	21,800	43,500	27,600	43,500	26,100				
		783	420	1,204	725	1,566	986	1,958	1,116	710	362	1,160	682	1,479	914	1,378	812				
16.7		1.2	4.7	2.2	2.8	3.0	3.6	3.1	3.7	2.2	5.6	3.4	4.1	4.1	4.9	3.0	3.6				
2.4	2.4	1.0	1.0	1.9	1.9	2.5	2.5	2.5	2.5	1.2	1.2	2.2	2.2	2.6	2.6	2.2	2.2				
140		392		392		392		392		392		392		392		392					
320		419		419		419		419		419		419		419		419					
HB		HB		HB		HB#		HB		HB#		HB		HB#		HB#					
HB		HB		HB		HB#		HB		HB#		HB		HB#		HB#					
1.0E+15	1.0E+13	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+11	1.0E+15	1.0E+12				
1.0E+15	1.0E+14	1.0E+13	1.0E+12	1.0E+14	1.0E+12	1.0E+14	1.0E+12	1.0E+14	1.0E+12	1.0E+13	1.0E+12	1.0E+14	1.0E+12	1.0E+14	1.0E+10	1.0E+14	1.0E+12				
813	889	889	762	1,016	889	1,016	889	1,016	889	1,016	889	1,016	889	1,016	889	1,016	889				
3.6	12.0	4.0	15	4.0	15	4.0	15	4.0	15			4.0	10	4.0	10	4.0	10				
3.2	5.5	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0			4.0	5.0	4.0	5.0	4.0	5.0				
0.04	2.00	0.005	0.50	0.005	0.50	0.01		0.01				0.005	0.20	0.005	0.20	0.005	0.20				
0.06	1.20	0.015	0.16	0.015	0.16	0.015	0.15	0.015	0.14			0.015	0.12	0.015	0.12	0.015	0.12				
	600		425		400		375		375		600		600		575						

Film grades of Durethan polyamide 6
and copolyamide are available.
For information, call 1-800-622-6004.

DURETHAN POLYAMIDE 6

Durethan Polyamide 6 (continued)

THERMOPLASTICS			Glass-Reinforced, Low-Warpage		Mineral-Reinforced		Mineral-Reinforced, Impact-Modified	
THERMOPLASTICS			BG 30 X 30% Glass Fiber/Bead		SM 230 H 30% Mineral		SM 240 H 40% Mineral	
THERMOPLASTICS			Dry as Molded		Dry as Molded		Dry as Molded	
THERMOPLASTICS			Conditioned		Conditioned		Conditioned	
GENERAL			1.35		1.36		1.46	
Specific Gravity	D 792	lb/in ³	0.049		0.049		0.053	
Density	D 792	in ³ /lb	20.5		20.4		19.0	
Specific Volume	D 792							
Mold Shrinkage:	(Miles)							
Flow Direction		in/in	0.007		0.012		0.010	
Cross-Flow Direction		in/in	0.008		0.012		0.010	
Water Absorption (0.125-in Thickness):		%	1.00		0.80		0.70	
24-Hour Immersion	D 570							
Equilibrium (73°F):	(DIN 53495)	%	2.1		2.0		1.8	
In Air (50% RH)		%	7.0		6.0		6.0	
In Water		%						
MECHANICAL			18,100		11,600		12,300	
Tensile Stress at Break	D 638	lb/in ²	9,400		7,300		7,300	
Tensile Elongation at Break	D 638	%	4		10		9	
Tensile Modulus	D 638	lb/in ² x 10 ⁹	899		725		870	
Flexural Strength	D 790	lb/in ²	28,300		20,300		22,500	
Flexural Modulus	D 790	lb/in ² x 10 ⁹	798		667		783	
Impact Strength, Notched Izod:	D 256	ft-lb/in	1.1		1.3		1.2	
0.125-in Thickness, 73°F		ft-lb/in	0.9		0.7		0.7	
0.125-in Thickness, -40°F								
THERMAL			356		194		221	
Deflection Temperature, Unannealed:	D 648	°F	392		374		392	
264-psi Load		°F						
66-psi Load								
FLAMMABILITY†			HB		HB ^a		HB ^a	
UL94 Flame Class:	(UL94)	Rating						
0.032-in (0.81-mm) Thickness		Rating						
0.062-in (1.57-mm) Thickness								
ELECTRICAL			1.0 E + 15		1.0 E + 15		1.0 E + 15	
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	1.0 E + 16		1.0 E + 14		1.0 E + 14	
Surface Resistivity	D 257	ohm	889		889		889	
Dielectric Strength:	(DIN 53481)	V/mil	4.5		5.0		5.0	
0.118-in Thickness			4.0		4.0		4.0	
Dielectric Constant (Tinfoil Electrodes):	D 150		0.015		0.015		0.015	
50 Hz			0.02		0.07		0.07	
1 MHz								
Dissipation Factor (Tinfoil Electrodes):	D 150		0.015		0.07		0.07	
50 Hz			0.02		0.07		0.07	
1 MHz								
Arc Resistance (Tungsten Electrodes)	D 495	s	110		575		575	
Comparative Tracking Index	D 3638	V	450		575		575	

* These items are provided as general information only. They are approximate values and are not part of the product specification.

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Miles value pending UL recognition.

^a Natural color.

Note 1

Dry as Molded: refers to a moisture content less than 0.2% by weight.

Conditioned: refers to an equilibrium moisture content in a standard laboratory atmosphere of 73°F and 50% relative humidity.

Note 2

Glass-Reinforced: refers to reinforcement with glass fibers except in the case of BG 30 X, which is reinforced with glass fibers and glass beads.

DURETHAN POLYAMIDE 6**Durethan Polyamide 6 (continued)**

Mineral/Glass-Reinforced				Reduced-Moisture											
				Glass-Reinforced				Glass-Reinforced, Impact-Modified							
				RM KU2-2501/30		RM KU2-2521/20		RM KU2-2521/25		RM KU2-2521/30		RM KU2-2521/35		RM KU2-2561/30	
				30% Glass		20% Glass		25% Glass		30% Glass		35% Glass		30% Mineral	
Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned
1.38		1.46		1.36		1.28		1.32		1.36		1.41		1.36	
0.050		0.053		0.049		0.046		0.048		0.049		0.051		0.049	
20.0		19.0		20.4		21.6		21.0		20.4		19.6		20.4	
0.005		0.005		0.003		0.003		0.002		0.002		0.002		0.012	
0.009		0.009		0.009		0.009		0.008		0.007		0.007		0.012	
				0.70		0.85		0.75		0.65		0.60		0.60	
2.0		1.8		1.5		1.5		1.4		1.3		1.2		1.4	
6.0		6.0		5.0		5.6		5.3		4.9		4.6		4.2	
17,400	9,400	18,900	13,100	25,400	16,000	20,300	11,600	21,800	16,000	23,900	16,700	26,100	18,900	12,300	7,980
3.5	13	3	7	3	4	4	8	4	5	3.5	5	3.5	7	5	30
972	493	1,160	798	1,450	812	1,090	725	1,232	798	1,378	870	1,595	957	798	435
27,600	14,500	29,000	17,400	42,100	26,100	31,900	19,600	34,800	21,000	37,700	22,500	42,100	24,600	22,500	10,900
899	406	942	493	1,300	783	942	522	1,058	580	1,276	725	1,450	870	725	362
1.2	1.9	1.1	1.9	2.1	2.6	2.4	3.2	2.8	3.6	3.2	3.9	3.6	3.9		
0.7	0.7	0.7	0.7	1.9	1.9	1.5	1.5	1.8	1.8	2.1	2.1	2.2	2.2		
374		392		383		374		374		374		374		179	
428		428		410		401		401		401		401		356	
HB		HB		HB		HB#		HB#		HB		HB		HB#	
HB		HB		HB		HB#		HB#		HB		HB		HB#	
1.0E+14	1.0E+13			1.0E+15	1.0E+12					1.0E+15	1.0E+12			1.0E+15	1.0E+13
1.0E+14	1.0E+13			1.0E+14	1.0E+12					1.0E+14	1.0E+12			1.0E+16	1.0E+15
1,016	1,016			1,016	889	1,016	1,016	1,016	1,016	1,016	889	1,016	1,016	762	762
5.0	15	5.0	15	4	10					4	10			4	8
4.0	4.5			4	4					4	4			4	4
0.007	0.02			0.004	0.029						0.032				
	600		500	0.005	115		600		600		108				
					600						600				

Film grades of Durethan polyamide 6
and copolyamide are available.
For information, call 1-800-622-6004.

TEXIN AND DESMOPAN THERMOPLASTIC POLYURETHANE

Texin Thermoplastic Polyurethane

THERMOPLASTICS			Polyester							
Typical Physical Properties			480-A	688-A	591-A	345-D	445-D	355-D	455-D	458-D
GENERAL Specific Gravity Shore Hardness Taber Abrasion: H-18 Wheel, 1000-g Load, 1000 Cycles Bayshore Resilience Mold Shrinkage at 100-mil Thickness: Flow Direction Cross-Flow Direction Processing Methods: • Injection Molding • Extrusion—Hose, Tubing, Profiles —Wire & Cable —Film & Sheet • Blow Molding Paintable Formulations Available *	D 792	A or D	1.20	1.26	1.22	1.22	1.22	1.22	1.21	1.22
	D 2240		87 A	88 A	88 A	45 D	45 D	52 D	55 D	60 D
	D 3489									
		mg Loss	15	50	40	45	70	50	50	45
	D 2632	%	45	35	35	40	45	40	40	45
	D 955									
		in/in	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
		in/in	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
		
		
MECHANICAL Tensile Strength Tensile Stress at 50% Elongation Tensile Stress at 100% Elongation Tensile Stress at 300% Elongation Ultimate Elongation Flexural Modulus Compression Set: As Molded (Postcured)** 22 Hours at 73°F 22 Hours at 158°F Shear Strength Tear Strength, Die C Impact Strength, Notched Izod: 0.125-in Thickness, 73°F 0.125-in Thickness, -22°F Instrumented Impact, Total Energy: 100-mil Thickness, 5 mph, 3-in Clamp 73°F -22°F	D 412	lb/in ²	6,000	4,500	6,000	4,500	6,000	5,000	6,000	6,000
	D 412	lb/in ²	720	900	1,150	1,250	1,100	1,800	1,800	2,400
	D 412	lb/in ²	750	1,000	1,200	1,400	1,300	2,000	2,000	3,000
	D 412	lb/in ²	1,700	2,000	2,800	2,500	2,600	3,100	4,000	4,700
	D 412	%	500	600	540	500	550	500	500	450
	D 790	lb/in ²	4,000	5,000	5,500	8,400	10,000	15,000	20,000	37,000
	D 395-B									
		%	16 (12)	21 (19)	16 (12)	16 (12)	18 (18)	17 (15)	20 (15)	40 (33)
		%	65 (35)	65 (40)	65 (35)	65 (30)	43 (35)	62 (35)	65 (35)	64 (40)
	D 732	lb/in ²							5,585	
	D 624	lb/in	500	650	750	700	700	900	900	1,000
	D 256						No Break 3.3			
		ft-lb/in								
	D 3763	ft-lb/in								
		ft-lb							42.6	
		ft-lb							36.9	
THERMAL Deflection Temperature Under Load: 264 psi 66 psi Coefficient of Linear Thermal Expansion Low-Temperature Brittle Point Glass Transition Temperature (T _g) Vicat Softening Temperature: Rate A	D 648	°F								
		°F								
	D 696	in/in/°F			8.3 E-05				139	131
	D 746	°F	<-90	<-40	<-90	<-90	<-90	<-90	<-90	<-90
	(DMA)#	°F	-44	-22	-33	-40	-51	-29	-15	3
FLAMMABILITY† UL94 Flame Class: 0.062-in (1.57-mm) Thickness	(UL94)	Rating	HB*						HB ^b	

* These items are provided as general information only. They are approximate values and are not part of the product specification.

** Postcured 16 hrs. at 230°F (110°C).

DMA: Dynamic Mechanical Analysis.

† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

a Natural color.

b Natural and black colors.

TEXIN AND DESMOPAN THERMOPLASTIC POLYURETHANE

Texin Thermoplastic Polyurethane (continued)

Polyester		Polyether			Polyurethane/Polycarbonate Blends						Medical			
360-D	470-D	985-A	990-A	970-D	3203	4203	4206	4210	4215	3215	5286	5187	5265	5370
1.23 60 D	1.24 70 D	1.12 86 A	1.13 90 A	1.18 70 D	1.22 60 D	1.21 60 D	1.21 65 D	1.21 70 D	1.21 75 D	1.21 75 D	1.12 86 A	1.20 87 A	1.17 65 D	1.21 70 D
55 42	90 55	30 45	25 40	75 50	90 40	70 42	80 46	65 45	85 52	80 55	30 45	15 45	75 50	65 45
0.008 0.008	0.008 0.008	0.008 0.008	0.008 0.008	0.008 0.008	0.008 0.008	0.008 0.008	0.008 0.008	0.008 0.008	0.008 0.008	0.006 0.006	0.008 0.008	0.008 0.008	0.008 0.008	0.008 0.008
.
5,000 2,400 2,700 3,400 500 30,700	6,000 4,100 4,300 5,200 350 105,000	6,000 650 700 1,100 550 3,900	5,000 950 1,000 1,750 550 6,000	6,000 2,500 3,000 5,200 375 55,000	4,500 2,700 3,300 300 31,000	5,000 2,500 2,700 325 30,000	5,000 3,700 4,000 200 60,000	6,000 4,100 4,500 180 100,000	6,000 4,600 5,300 150 150,000	6,000 4,800 5,200 175 150,000	6,000 650 700 1,100 550 3,900	6,000 720 750 1,700 500 4,000	6,000 2,900 3,300 4,450 460 55,000	6,000 4,100 4,500 180 100,000
20 (15) 40 (25)	50 (30) 85 (45)	19 (16) 80 (40)	20 (13) 75 (35)	40 (25) 75 (45)		3,920 850	5,300 800	6,200 900	7,300 950		19 (16) 80 (40)	16 (12) 65 (35)	28 (20) 88 (35)	
1,000	1,300	500	550	1,100	750	13	13 1	16 1	18 1.5	15	500	500	1,200	900
					42.0 41.0	44.1 40.9	33.1 39.6	35.8 40.5	39.1 42.9	36.0 44.0				
133 7.2 E-05 <-90 -20 315	115 5.5 E-05 <-90 32 316	<-90 -51 176	<-90 -47 223	113 155 6.4 E-05 <-94 32 306	114 144 <-90 -11 302	99 131 7.0 E-05 <-90 -27 295	109 150 5.8 E-05 <-70 -27 286	139 208 5.7 E-05 <-90 -31 282	166 227 5.0 E-05 <-90 -31 284	183 231 8.9 E-05 <-90 0 295	<-90 -51 176	<-90 -44 197	<-90 14	139 208 5.7 E-05 <-90 -31 282

BAYFLEX ELASTOMERIC POLYURETHANE RIM

Bayflex
Elastomeric RIM

THERMOSETS			MP-5000	MP-10000	110-25 IMR	110-50		XGT-100	
Typical Physical Properties			Unfilled	Unfilled	Unfilled	Unfilled	15% Glass ¹	Unfilled	15% Glass ¹
GENERAL									
Specific Gravity	D 792		1.0	1.0	0.98	1.04	1.15	1.04	1.15
Density	D 1622	lb/in ³	62.4	62.4	61.2	63	71.2	65	72
Thickness		in	0.118	0.118	0.125	0.125	0.125	0.125	0.125
Shore Hardness	D 2240	A or D	30 D	40 D	50 D	58 D	60 D	69 D	70 D
Mold Shrinkage	(Miles)	%	1.25	1.4	1.4	1.4	0.5-0.6	0.75-0.85	0.55-0.75
Water Immersion, Length Increase	(Miles)	in/in	0.015	0.014	0.008	0.006	0.002		
Water Absorption:									
24 Hours		%	3.3	3.3			2.6		
240 Hours		%	5.0	5.0	2.8	2.8			
MECHANICAL									
Tensile Strength, Ultimate	D 638/D 412	lb/in ²	1,900	2,200	3,000	3,200	2,900	4,600	4,100
Elongation at Break	D 638/D 412	%	360	300	260	220	83	100	50
Flexural Modulus:	D 790								
149°F		lb/in ²	4,000	7,900		38,000	60,000	43,000	94,000
73°F		lb/in ²	5,000	10,000	25,000	51,000	100,000	100,000	210,000
-22°F		lb/in ²	14,500	23,600		115,000	160,000	200,000	403,000
Flexural Strength	D 790	lb/in ²							
Tear Strength, Die C	D 624	lb/in							
Compressive Strength	D 395	lb/in ²							
Impact Strength:									
Charpy Impact		ft-lb/in ²			8	11	8	9	4.3
Notched Izod	D 256	ft-lb/in							
Unnotched	D 256	ft-lb/in							
THERMAL									
Deflection Temperature Under Load:	D 648	°F							
264 psi		°F							
66 psi	D 3769	in			0.51	0.60	0.28	0.67	0.54
Heat Sag:		in				0.36	0.27	0.67	0.54
6-in Overhang, 1 hr at 250°F		in				78 E-06	44 E-06	58 E-06	28 E-06
4-in Overhang, 1 hr at 250°F		in/in°F							
Coefficient of Linear Thermal Expansion	D 696								
FLAMMABILITY†									
UL94 Flame Class:	(UL94)	Rating							
0.125-in Thickness									
0.250-in Thickness									

* These items are provided as general information only. They are approximate values and are not part of the product specifications.

† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

¹ Milled glass fiber, OCF 737, 1/16 inch.

² Directed chopped fiber preform.

³ Continuous strand mat.

Note 1

All directional properties are listed parallel to flow.

Note 2

IBS: Interactive Blowing System.

IMR: Internal Mold Release.

RIM: Reaction Injection Molding.

XGT: Extended Gel Time.

BAYDUR STR COMPOSITE POLYURETHANE RIM
BAYDUR STRUCTURAL FOAM POLYURETHANE RIM
PRISM SOLID POLYURETHANE RIM

Baydur STR
Composite RIM

STR/C-400 BB	STR/F-350 IMR
60% Glass*	17% Glass*
1.71 107 0.160 0.05 0.35 0.98	0.50 32 0.125 0.10
32,100 1.8	2,900
2,120,000 62,600	220,000 6,700
30.7	6.5
416	209
7.8 E-06	0.04 7.8 E-06

Baydur
Structural Foam RIM

D-15	660 IBS	730 IBS	726 IBS
Density 20 pcf	Density 25 pcf	Density 35 pcf	Density 35 pcf
0.32 20 0.500 40 D	0.40 25 0.500 57 D	0.56 35 0.500 70 D	0.56 35 0.250 65 D 0.7-0.9
1,000 6	1,300 7	2,800 7	2,000 10
53,000	76,000	113,000	125,000
900	1,200	2,800	170,000
2.2	4.8	6.3	8.2
149	199	219	158
			176
			181
			212
			V-0/5VA

PRISM
Solid RIM

CM-200
Density 61 pcf
0.98 61 0.125 73 D 0.7-0.9
5,500 11
267,000 9,300
5
192
0.29
V-0/5VA

BAYTEC RE POLYURETHANE SPRAY SYSTEMS BAYTEC RTM POLYURETHANE SYSTEMS FOR RESIN TRANSFER MOLDING

			Baytec RE Spray Systems					Baytec RTM Molding Systems		
			RE 525		RE 632	RE 527		RTM 532		
			Unfilled	30% Mineral ¹	Unfilled	Unfilled	7% Glass ²	Unfilled	20% Glass ³	40% Glass ³
THERMOSETS Typical Physical Properties GENERAL Specific Gravity, 77°F Density, 77°F Shore Hardness Taber Abrasion: H-18 Wheel, 1000-g Load, 1000 Cycles Bayshore Resilience Mold Shrinkage Processing Methods: • Casting • Spray • Resin Transfer Molding Paintable •	D 792		1.05	1.11	0.96	1.16	1.2	1.18	1.28	1.44
	D 792	lb/ft ³	66	69	60	72	75	74	80	90
	D 2240	A or D	85 A/38 D	65 D	66 A	75 D	80 D	81 D	82 D	84 D
	D 4060									
	D 2632	mg Loss	217	908	350					
	(Miles)	%				1.1	0.4	2	0.12	0
		%								
MECHANICAL Tensile Strength Tensile Stress at 100% Elongation Tensile Stress at 200% Elongation Tensile Stress at 300% Elongation Ultimate Elongation Flexural Strength: 77°F 150°F Flexural Modulus: 77°F 150°F Shear Strength, Compressive Lap: Polyurethane - Acrylic Polyurethane - ABS Compression Set: 22 Hours at 158°F Compression Deflection: 5% 10% 25% Tear Strength: Die C Tear Split Tear Impact Strength, Notched Izod: 0.125-in Thickness, 77°F Instrumented Impact, Total Energy: 0.100-in Thickness, 77°F	D 412	lb/in ²	750	1,070 ⁴	900	7,000	8,000	7,200 ⁴	14,500 ⁴	25,000 ⁴
	D 412	lb/in ²			320					
	D 412	lb/in ²			460					
	D 412	lb/in ²			600					
	D 412	%	65	50 ⁴	490	6	4	8 ⁴	4 ⁴	4 ⁴
	D 790	lb/in ²				10,200	12,400	11,300	22,000	35,000
		lb/in ²						3,700	12,900	20,500
		lb/in ²		7,100		287,000	403,000	300,000	650,000	1,000,000
		lb/in ²						105,000	400,000	740,000
	D 3846	lb/in ²				>2,000	>2,000			
THERMAL Deflection Temperature Under Load: 264 psi 66 psi Coefficient of Linear Thermal Expansion, 122°F (Miles)	D 395-B	%								
	D 575	lb/in ²			50					
		lb/in ²			90					
		lb/in ²			210					
	D 624	lb/in	120		160					
	D 1938	lb/in	50		90					
	D 256	ft-lb/in				0.5	1.5	0.6	6	10
	D 3763	ft-lb				0.31	3.5	0.2	6	10
				1.9						
FLAMMABILITY† UL94 Flame Class at 0.125-in Thickness ANSI Z-124.1, 5.6 (1987) ANSI C37.20.2, 5.2.7	D 648	°F						130	260	390
		°F						160	420	>425
	(Miles)	in/in°F				41 E-06	17 E-06	43 E-06	9 E-06	7 E-06
	(UL94)	Rating				HB	HB			
	(ANSI)	Rating				Pass	Pass			
	(ANSI)	Rating				Pass	Pass			
ELECTRICAL Dielectric Strength Arc Resistance	D 419	V/mil	322	122	366					
	D 495	s	121	122	123					

- * These items are provided as general information only. They are approximate values and are not part of the product specifications.
 † Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.
⁴ Tested in accordance with ASTM D 638.
¹ Calcium carbonate.
² 0.250-inch chopped fiberglass roving.
³ Continuous strand mat.

Note 1
All cast elastomer properties refer to uncatalyzed and postcured materials (postcured for 16 hours at 230°F/110°C).

Note 2
PTMG: Poly(tetramethylene ether) glycol
PG: Poly(propylene ether) glycol

BAYTEC POLYURETHANE PREPOLYMERS FOR CAST ELASTOMERS

Baytec

Prepolymers (Cured with 1,4-Butanediol)

PTMG				PG		Polyester						
ME-040	ME-050	ME-080	ME-090	MP-090	MP-100	MS-041	MS-051	MS-061	MS-081	MS-090	MS-092	MS-242
79 A	85 A	93 A	95 A	85 A	90 A	72 A	80 A	87 A	90 A	93 A/47 D	93 A/43 D	85 A
12	15	20	25	90	84	10	16	24	26	38	30	30
65	63	60	60	20	20	52	52	44	44	26	43	32
.
4,200	4,600	5,100	5,400	5,000	4,800	5,100	5,360	6,500	6,600	7,500	6,870	7,150
600	840	1,150	1,560	990	1,640	460	640	900	1,110	1,500	1,480	830
940	1,150	1,500	2,000	1,580	2,750	620	870	1,250	1,500	2,590	1,960	1,215
1,200	1,670	1,900	2,600	2,750	4,290	820	1,180	1,730	2,350	3,800	2,600	1,750
480	480	490	500	410	315	560	525	525	500	480	510	575
17	16	18	17	45	35	20	24	18	20	35	22	24
140	180	250	320	130	165	70	105	160	220	310	275	170
180	370	490	575	275	360	145	220	280	425	600	530	300
520	885	1,090	1,180	750	1,080	410	570	680	930	1,350	1,200	740
340	415	555	610	360	380	325	380	550	575	705	675	525
80	90	100	140	90	90	100	105	175	200	400	275	300

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INFORMATION**

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INFORMATION**

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INFORMATION**

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Polyurethane Handbook

Chemistry – Raw Materials – Processing
Application – Properties

Edited by Günter Oertel

2nd Edition

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Preface

Since its publication throughout the all areas of polymer technology. In the 1990s, we were completely new

During the "first generation" of diisocyanate) technology, the markets far beyond

The rapid growth maintained in the and developing light of this rapid mental concern volume, while years, is still in

Over the years, it has achieved some unique use of polyurethane logical and economic

The polyurethane key environmental management, a

The success of achieving the balance and the environment

I would like to represent the content of Ms. Kindermann

the editorial team their invaluable

Like its predecessor, Stoff-Handbuch, 1993. At this point

term "polyurethane" only correct for the, is nevertheless we have decided

This volume was written at Miles Inc. team for their effort the technical quality

February 1993

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*R. Bock, Dr. M.**Dr. R. Zöllner*

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3.4 Additives and Auxiliary Materials

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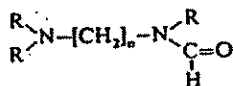
Table 3.9. Relative Activity as a Function of Concentration and Synergism of Typical Commercially Used Catalysts [2]

Catalyst	Concentration %	Relative reactivity
uncatalyzed	-	1
TMBDA	0.1	56
DABCO	0.1	130
TMBDA	0.5	160
DBTL	0.1	210
DABCO	0.2	260
DABCO	0.3	330
SnOct	0.1	540
DBTL	0.5	670
DBTL + TMBDA	0.1 + 0.2	700
SnOct + TMBDA	0.1 + 0.2	1000
DBTL + DABCO	0.1 + 0.2	1000
SnOct + TMBDA	0.1 + 0.5	1410
SnOct + DABCO	0.1 + 0.5	1510
SnOct	0.3	3500
SnOct + DABCO	0.3 + 0.3	4250

TMBDA = Tetramethylbutanediamine
 DABCO = 1,4-Diaza(2,2,2)bicyclooctane

DBTL = Dibutyltin dilaurate
 SnOct = Tinoctoate

Further, polyamines partially neutralized with formic acid [10] have attained significance as delayed action catalysts for semirigid and flexible molded foams. In recent years, a new latent catalyst was described that is noncorrosive and nonvolatile (no smell). The basis is the chemically blocking of the active amine by a component whose structure was not disclosed [11]. The product is used for flexible and semirigid foam. Because of industrial hygiene concerns, the N-acylated amines [12] as low odor catalysts are of interest for foam manufacture:



All terms and measuring procedures for the simple description of the kinetics of the polyurethane reaction are derived from industrial practice and observations of macroscopic phenomena. They are based on the following steps as a function of time:

- Mixing time (stirring time) is the duration of the time of mixing the components.
- The cream time (gel time, start time) is the time lapse from the beginning of the mixing process until a visual change or a distinct rise in the viscosity and the volume of the reaction mixture occurs.
- The rise time (only for foams) is the time span from the beginning of mixing to the end of the rise of the foam.
- The setting time (curing time) is the time span from the beginning of mixing until a point is reached where the polyaddition product no longer flows. According to the working procedure and the product, the determination of the setting time follows different criteria. Figure 3.4 shows that the reaction is not at all finished within the set time. Only a fraction of the total reaction rate is described by the described times. The complexity of the course of reaction is best described by the variety of terms used in practice, i.e., "post-pressure time", "tack free time", "string time", "pluck time".

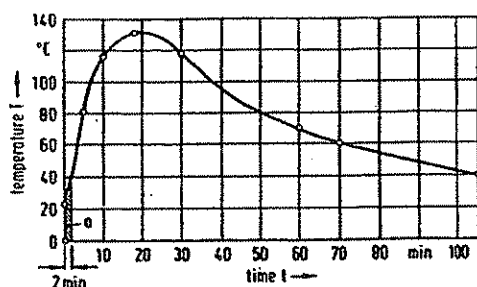


Fig. 3.4. Accessible measurable range of a specific application of a PU reaction (example: 275 g preparation of PU rigid foam, apparent density 22 kg/m³) a = area between stirring and tack-free time

- The mold release time is the time span from the mixing of the components until the earliest possible removal of the finished part ("green strength"). Cycle time is greater than the molding process time and includes mold preparation and post treatment (cleaning, mold release agents and taking out parts).
- Final curing time is the time span until the final curing of the finished part. This will be widely different based on the product and process (hours, days weeks) as well as temperature and humidity effects (compare section 5).

3.4.1.2 Catalysis for NCO/NCO Reactions

The catalysis for dimerization to uretdiones, the carbodiimide formation, and the currently less important linear polymerization of isocyanates to polyamide-I has already been described in subsection 2.1.2.2 and 3.3.2.2. The trimerization reaction for the manufacture of solid and cellular polyurethanes has far greater significance.

Isocyanurate structures give polyurethanes a higher heat resistance and improve intrinsic fire retardance. Since pure polyisocyanurates lead to very brittle products, in practice PIR/PUR combinations are used exclusively [13]. As a result, two reactions running concurrently must be catalytically controlled: the NCO/OH and the trimerization reaction. In this regard, the catalysts for the isocyanurate formation have been thoroughly investigated [13 to 16]. In Table 3.10 the trimerization catalysts are collected according to structural types.

Table 3.10. Typical Structures of Trimerization Catalysts

$R^1R^2R^3N$	Amines
R_3P	Phosphines
$R-OMe$ (Me = z. B. Alkali)	Alcoholates
Me_2O	Metal oxides
$RCOOMe$ Me = K, Na, Ca, Fe, Mg, Hg, Ni, Pb, Co, Zn, Cr, Al, Sn, V, Ti	Carboxylates
$R-Me$ Me = Zn, Si, Sn, Pb, Sb	Organo metal compounds
R_2Me	
R_3Me	
org., inorg., Lewis-acids	Metal-Chelates
Amine-epoxides	Hydrides
Amine-alkylenecarbonates	Acids
Amine-imides	Combined catalysts

From this schemat



alkali salts of low catalyst combination there are known as tertiary ammonium

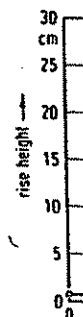


and special aminin



3.4.1.3 Catalysis

The commercially cools (see subsection distribution of the different reactivity basic isocyanates, tion 3.3.2) of different PUR applications (amines, peralkyl laurate, N-alkyl m New polyurethane foams (RIM techn special demands c thanes, especially combinations.



In flexible foams. amine/tin catalysts

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